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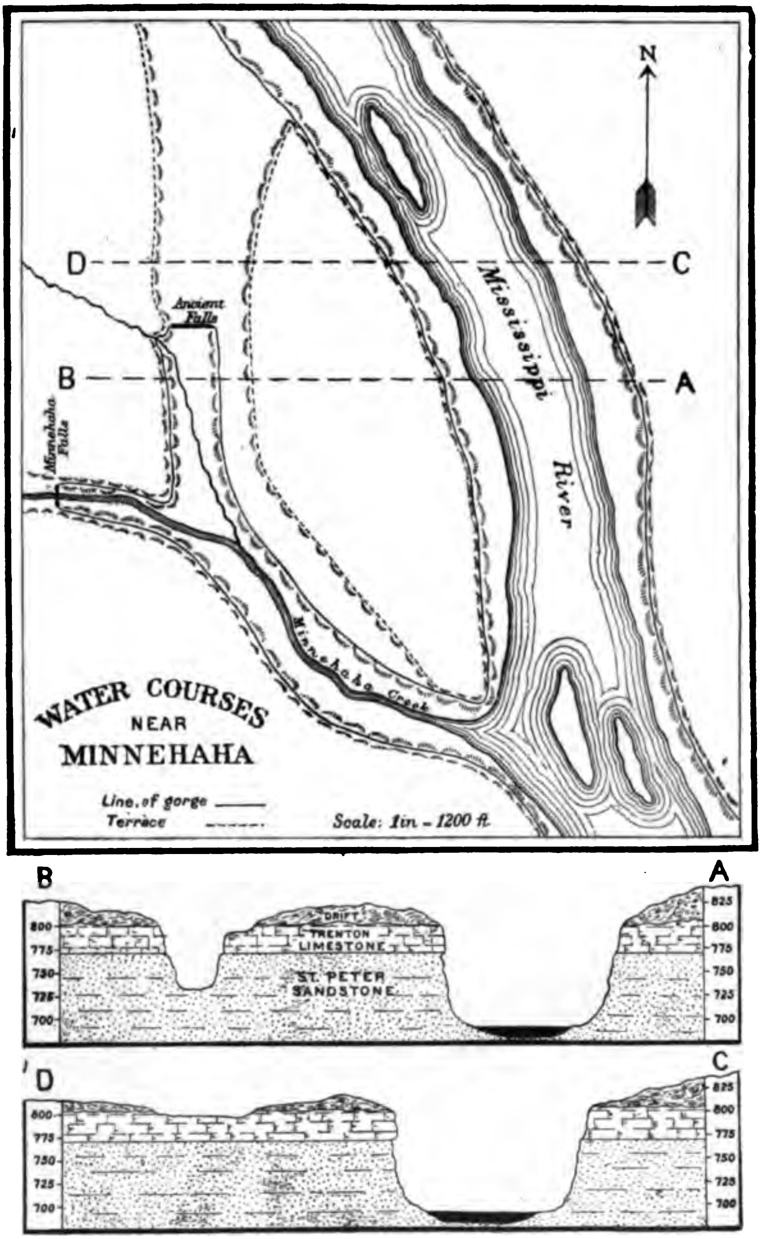
ERRATA FOR VOL. V.

Page 30, note 2, read 1851 for 1859.
31, note 4, read vol. 9, for vol. 19.

ERRATA FOR VOL. VI.

Page 62, 9th line for superviency read subserviency.
201, 4th line from the bottom, read 2710 for 2701.
269, 18th line from the top, before "of" insert, be the equivalent.
284, 7th line from bottom, read shape, instead of shade.
286–290, for ash, or ashes, read debris.
331 in footnote 17 for 256–8, read 265–8.
332, line 15 for Nachoak read Nachvak.
345, line 7, for Blastoidæ read Blastoidea.
347, tenth line from the bottom, for Tecunocrinus read Technocrinus.
348, eighth line from the bottom, for fine read five.
351, ninth line from the bottom, for (III) read (Ill).
357, fifteenth line, for Americanus, read americanus.


N
D
C
B
A
Ancient Falls
Minnehaha Falls
Mississippi
River
Minnehaha Creek
WATER COURSES
NEAR
MINNEHAHA
Line of gorge
Terrace
Scale: 1in = 1200 ft.
B
A
DRIFT
TRENTON LIMESTONE
ST. PETER SANDSTONE
825
800
775
750
725
700
D
C

THE

AMERICAN GEOLOGIST

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ACCOUNT OF A DESERTED GORGE OF THE MISSISSIPPI NEAR MINNEHAHA FALLS.

By ULY S. GRANT, Minneapolis.

The present topography of any region, aside from a mountainous one—and even then to a great extent—is due almost entirely to the erosive power of water. The results which are most generally ascribed to this cause, probably because they form very striking features of our landscapes and can still be seen in the process of formation, are the channels cut by great rivers, especially the rock-bound passages usually termed cañons in the western states. One of these smaller channels, perhaps more appropriately called a gorge, will be briefly described; and a few of the accompanying minor results of erosion will be mentioned in regard to their assistance in the base leveling of a given area,—a subject which has been discussed recently in reference to the drainage of Pennsylvania.[1] It is not to be supposed that the comparatively insignificant effects here described are of great importance in the general planing off of large areas, but they undoubtedly are of considerable importance in the leveling of limited drainage basins, particularly in regions having a geological structure similar to that of the one under consideration.

From the falls of St. Anthony to Ft. Snelling, a distance of

[1] W. M. Davis: Nat. Geog. Mag., v. I, p. 183; Amer. Nat. v. XXIII, p. 566.

over eight miles, the Mississippi flows in a deep gorge of somewhat less than a fourth of a mile in width. The falls have receded from Ft. Snelling to their present position since the retreat of the ice-sheet from within the limits of Minnesota.[2] Two miles above Ft. Snelling, Minnehaha creek enters the Mississippi through a small gorge from the west. The rocks of this region are covered by drift averaging, where the river has cut through it, perhaps not more than thirty feet in thickness. Immediately below the drift occur the practically horizontal beds of Trenton limestone, having a thickness of twenty-seven feet, as is shown at the brink of Minnehaha falls. The upper and lower beds are of comparatively soft shales, but the greater part is of hard, compact limestone. The Trenton lies conformably on the St. Peter sandstone, which is quite friable, generally possessing very little or no cementing material. The limestone forms the brink of every water-fall within this area, and in no place have the streams as yet cut entirely through the sandstone.

From its falls to the Mississippi, Minnehaha creek flows in a narrow gorge cut through the Trenton and some thirty feet into the St. Peter. The upper part of this channel (the gorge proper of Minnehaha) is less than two hundred feet wide and extends eastward for about six hundred and fifty feet; at this point the channel enters an older gorge and widens abruptly to twice its original width and thence continues in a southeasterly direction undiminished to the Mississippi,—a distance of two-thirds of a mile. From the point where the channel so suddenly expands, the older gorge not only runs, as before stated, southeastward to the river, but also extends northward for some three hundred yards and ends abruptly.[3] Beyond the northern termination of this part of the gorge, which is now deserted, a low, level plain, much wider than the deeper channel below, passes northward and its upper end is seen to join the great gorge of the Mississippi at the top of the limestone ledge. Each side of this level area is sharply defined by a terrace sloping back to the higher land on each side. These terraces evidently represent the banks of a former

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[2] *Vide* Geol. and Nat. Hist. Survey of Minn., v. II, pp. 313-341.

[3] Prof. N. H. Winchell and Prof. G. F. Wright were the first to notice the northward extension of this gorge; the former called the writer's attention to it.

stream, and can be traced northward, the whole length of the depressed plain, until they are cut by the Mississippi gorge. The eastern one is also seen running southward to the river and keeping nearly parallel with, but a few rods east of, the larger gorge in which Minnehaha now flows. Part of the water of the Mississippi manifestly once flowed along this level area and, plunging down over its abrupt southern end, which marks the locality of an ancient water-fall, followed the present course of Minnehaha to the river. (The channels referred to are shown in the accompanying map and sections.)

Prior to the recession of the falls of St. Anthony from Ft. Snelling to the present mouth of Minnehaha creek, the Mississippi was flowing in a broad shallow channel, in which there were very probably many islands. The remains of one of these islands are seen just above the junction of the two streams. When the falls had reached the lower end of this island, they were divided,—one part going to the east of the island and the other to the west. The stream on the eastern side was much the larger and the growth of its gorge more rapid, reaching the upper end of the island before the stream on the western side had eaten back to the same point. Thus the water of the latter stream was intercepted and carried down by the other, leaving the present deserted channel. No case similar to this has been personally noticed in the Mississippi gorge, although further search might reveal several additional instances. At the present time, however, St. Anthony falls are divided by an island in such a manner that one channel has approximately only one-third the volume of water of the other. If the wearing back of the falls here had not been artificially stopped, in all probability another deserted gorge, exactly similar to the one described, would have finally resulted, the deserted rock brink being on the east side of Hennepin island.

While the upper Mississippi still continued to receive large amounts of water from the melting of the retreating ice-sheet, towards the end of the second glacial period, its volume was much larger than now, and it was flowing in a broad channel many times the width of the present one.[4] After the ice had retreated so that the water flowing from it was drained to the sea in another direction, the Mississippi decreased to about its

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[4] Geol. and Nat. Hist. Survey of Minn., v. II, p. 337.

present size and then, but not before, cut its channel down through the drift to the Trenton limestone. As the hard limestone layers offered considerable resistance to erosion and as the drift banks offered much less, the river would be compelled to widen its channel rather than to deepen it; thus a broad, shallow stream would result. That the river had worn down to the limestone and was flowing along its surface long before cutting its gorge is noticed in several places. It is especially well shown in the wide shallow channel above the ancient falls, where the limestone layers are everywhere at the surface, being covered by only a few inches of soil which has accumulated since the water was drained from this channel. (Compare section CD.)

Another subject of noteworthy interest in this connection is the fact that the river did not cut its gorge of the same width as the channel in which it was flowing just before wearing through the limestone. In many places are found the remnants of old river terraces several rods beyond the limits of the gorge. This is shown on a small scale in the deserted channel described, where the distance between the terraces is much greater than that between the walls of the gorge, and there are no intermediate banks showing a diminution of the water or a narrowing of the channel after these terraces were formed and before the gorge was cut. And again, the Mississippi above the falls of St. Anthony has a much greater width than has the gorge below the falls. This could be explained by the stream's wearing away the limestone more rapidly at one side of the brink of the falls than at the other on account of its greater depth or on account of the softness of the rock; if once begun this would be continued by additional water which would be drawn to this point, and so one side of the falls would recede more rapidly than the other: and as a consequence, more and more water would be directed to this part of the channel until a portion of the brink had no water flowing over it, and would remain stationary. Thus it is probable that the river at first cut its gorge of width only sufficient to carry its volume of water; the size of the gorge has since been slightly increased by other causes mentioned below.

The effect of islands in rivers on the hastening of the final result of erosion,—the leveling of the drainage basin,—is of considerable importance. In the case under consideration

the river, after dividing, cut back its gorge much more slowly than when all its water was flowing in one channel; hence one effect is to decrease the rate of recession of falls. But on the other hand, the actual width of the two gorges taken together is greater than that of the gorge formed by the stream when undivided; so the width of the gorge is not directly proportional to the volume of the stream cutting it. That the gorge on the east side of the old island is of the same width as it is both above and below this point, is not due to the fact that it was originally cut of this size, but that it was enlarged after the water was again collected into the main channel. As the gorge proper of Minnehaha creek and that of the Mississippi remain practically constant in width throughout their courses, and for other reasons, it may be concluded that the respective volumes of these streams have also remained constant during the formation of their gorges. A comparison of these two gorges shows, as before stated: (1) That a smaller stream eats its way back much more slowly than a larger one; the Mississippi has cut its gorge from the old island to the present site of St. Anthony falls,—a distance of six miles,—in the same time which Minnehaha creek has required to cut a gorge of less than seven hundred feet in length. Prof. N. H. Winchell has calculated the average rate of recession of the falls of St. Anthony to be about five and a half feet per year;[5] from this determination Minnehaha falls would recede about one-tenth of a foot per year, or ten feet in a century. (2) That the width of a gorge is not directly proportional to the volume of the stream cutting it; the ratio between the width of Minnehaha gorge and that of the Mississippi is as one to five, but the volumes of the two streams are more as one to thirty.

In this connection it is to be noticed that it is almost impossible, unless a very long period of time is allowed, for the smaller streams to cut through the hardlime rock; but when once an opening has been made by the river, these streams rapidly increase the size of the opening by erosion of its edges and especially by the wearing away of the softer sandstone below, thus undermining and causing large blocks of the limestone to become detached. The width of a gorge is often materially increased by these smaller streams and by the rills from every shower; from this cause the gorge in close prox-

[5] Geol. and Nat. Hist. Survey of Minn., v. II, p. 337.

imity to a fall is much narrower than it is a short distance below that point. This element in the widening of a gorge is of some importance, but as it proceeds, unless the river changes its course and wears into the bank, the tendency is to round off the sharp outlines and to make the slopes more gentle, thus decreasing the rapidity of further erosion in the rock. This is very nicely shown in the deserted gorge, where the subduing process has gone on uninterruptedly and the banks are, although comparatively steep, not in the least perpendicular, as they formerly were; the rock outcrops are concealed and almost completely protected from further erosion by débris washed down from above. The same thing is shown at many points in the Mississippi gorge where the river does not flow near the side of the gorge. The streams of this region are by no means overloaded with suspended sediment; so in addition to what material they transport from the drift, they are prepared to take up and carry away large amounts of detritus from below the limestone.

The effect of islands in a river would then be to decrease the speed with which the river cuts back its channel, but to increase the total width of the channels cut. There would thus apparently be a larger amount of material removed in a given time; but even if the amount was not increased by this cause, it would be by the additional sediment transported by the smaller streams. Hence the final effect is to accelerate the rapidity of the leveling of the drainage basin.

The depth of the gorge has not been taken into consideration, as the river very rapidly cuts down into the sandstone after it has once made an opening through the lime rock.

GENERIC RELATIONS OF PLATYCERAS AND CAPULUS.

By CHARLES R. KEYES.

In 1840 Conrad[1] established the generic term Platyceras for a certain group of paleozoic gasteropods having *P. ventricosum* Con. for its typical representative. By most American and some European writers since that time, this name has been frequently used in the description of forms more or less closely resembling the type of Conrad's genus. Other terms, Acroculia, Orthonychia, Igoceras, etc., have been proposed from time to

[1] Ann. Rept. N. Y. Geol. Sur., p. 205.

time for forms now generally considered congeneric with Platyceras. But of late years many European authors have been inclined to regard the shells of the group in question as referable to the modern genus Capulus founded in 1810 by Montfort; though Œhlert[2] has recently revived Phillips' Acroculia,[3] proposed in 1841.

As regards the real generic characters of the different species, their specific limitations, range of variability and the geologic and geographic distribution of the various forms, greater confusion perhaps nowhere exists among fossil mollusks than in the group under consideration. This want of agreement among writers concerning the main features presented by the individuals of the various species is directly traceable to a number of causes. These, however, need not be reviewed here. Nor is it the intention in the present note to attempt a removal of the difficulties; but merely to call attention to several pertinent facts regarding the structural features of the fossil shells hitherto commonly referred to Platyceras of Conrad.

The most salient characters of recent Capulus, as shown by the more typical shells, are the more or less obliquely conical form, the small, often closely incurved spire, the broad, campanulate, apertural portions and the characteristic muscular impressions on the interior of the shell. The close relations of such paleozoic shells as *Platyceras paralium* W. & W. and *P. equilaterum* Hall and the modern forms of Capulus, as *C. hungaricus* Linn., can hardly be denied after even a casual comparison. The affinites are not less striking in many of the other forms. Nor are examples wanting from the Mesozoic.

The three hundred species which have been ascribed to Platyceras present such a great variety of forms that it is difficult to foresee just how they can be most satisfactorily arranged when they have been carefully considered anew and in relation to one another. The placing of Platyceras, Orthonychia and other sections as subgenera under Capulus, as has been done by Zittel,[4] and others, manifestly does not meet the requirements, at least so far as the American species are concerned. Whether or not the forms can all be included under Capulus remains for future comparison to decide. It

[2]Bul. de la Soc. Géol. de France, (3), t. xi. p. 602.
[3]Palæ. Foss. Cornwall, p. 93.
[4]Handb. der. Palæontologie, II Band. p. 216.

seems very probable, however, that a number of the so-called Platycerata will be shown by further study to belong more properly to genera closely allied to Capulus rather than to the genus itself. This would carry back the antiquity of certain modern groups somewhat beyond what has hitherto been considered. A recent critical examination of certain shells described as Platycerata also shows that some of these forms are members of families entirely different from that supposed.

Even if the group to which Conrad gave the name Platyceras was a valid one, it is very questionable whether the term could stand, inasmuch as it had been practically pre-occupied for nearly three-quarters of a century. It has long been known that Geoffroy[4] in 1764 proposed, among Coleoptera, the generic name Platyceras, a term which was later employed by Latreille,[5] and which continues to the present day in good usage as originally founded. In so far as the species hereafter mentioned are concerned, it matters little whether or not the type of the genus Platyceras—*P. ventricosum* Con.—be a true Capulus; but certain it is that some of the forms described under the former title are generically identic with the latter group.

It is well known that the species that have been included under Platyceras present a large variety of forms. And lately it has been further shown that in this group variation is very great even among individuals of the same species. The manifold phases thus disclosed have resulted from the sedentary habits of the mollusks; and in a number of species the foreign objects of attachment have proved to be the calyces of crinoids. The evidence, however, bearing upon this question has been given with considerable detail elsewhere[6] and is only incidentally referred to here. Several hundred examples of this kind embracing ten or a dozen different species of Platyceras and more than twenty species of crinoids show rather conclusively that the sedentary propensities of many of these fossil forms were not unlike those of the living representatives. The occurrence of gasteropods on crinoids as thus brought out has given rise to a belief, quite prevalent, that these mollusks were parasitic in their habits; but lately this has been

[4] Hist. abrégée des Insectes, 1764.
[5] Précis des Caractères, des Insectes, 1796.
[6] Keyes: Proc. Am. Philosophical Soc., vol. xxv, 1888.

amply shown not to be the case. There are no grounds whatever for the assumption that the paleozoic Capuli led parasitic lives.

In this connection it may be stated that there is often considerable embarrassment in attempting to separate certain ancient Capuli on the one hand from some forms of Platyostoma, and especially from those species in which there is a greater or less tendency for the shells to uncoil; and on the other hand from various genera of patelloid shells.

As might be expected in a group of gasteropods presenting so few constant characters that can be satisfactorily relied upon in classification, it is often impossible to clearly distinguish between certain species of paleozoic Capulus. Many structural features long regarded as of much importance in identification are now known to possess little, if any, specific value, owing to their great variability. It has thus become necessary to consider as of the utmost significance the basis of species upon general resemblances rather than upon unimportant variant characters, due to the diverse condition of environment which arises from a more or less extensive geographic and geologic range. Therefore in the selection of characters for classificatory purposes it is evident that only those features showing the least tendency to change are available.

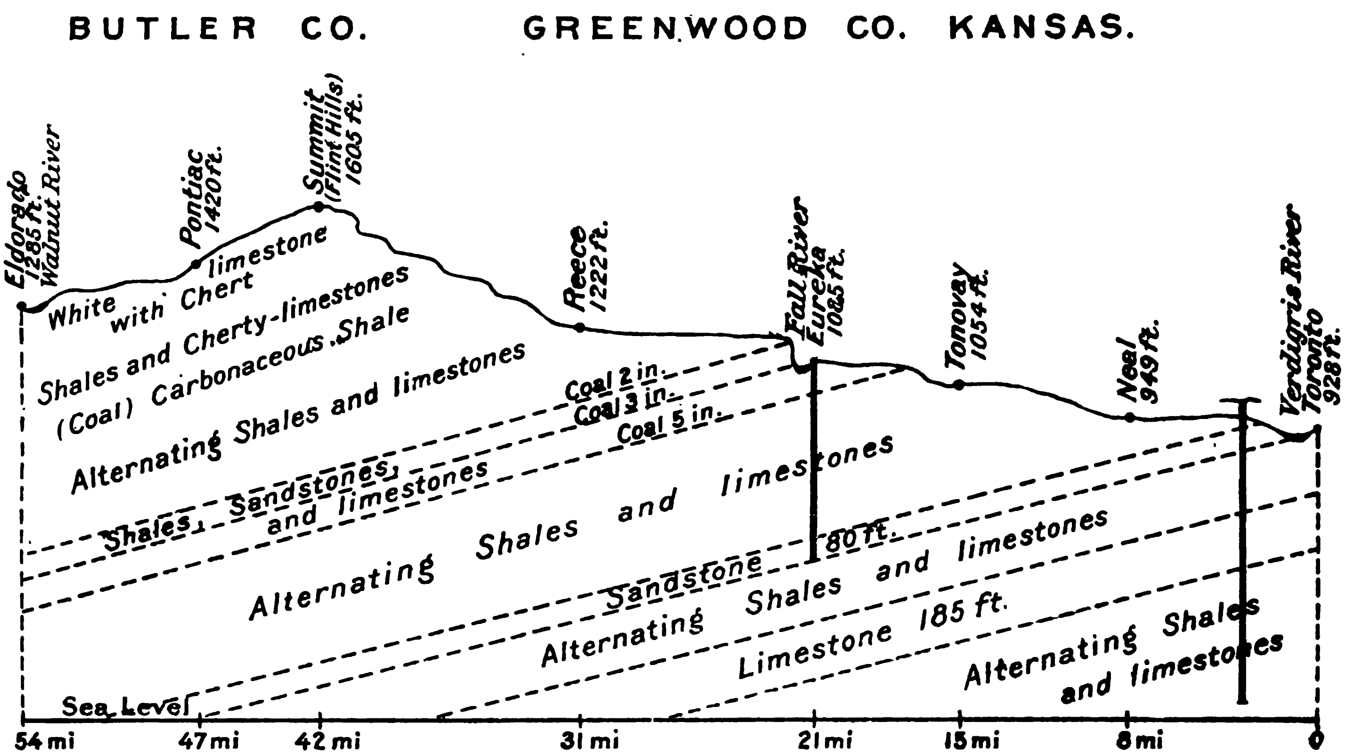
The following forms, originally described under Platyceras, appear properly to belong to Capulus. Doubtless quite a number of other American species that have been referred to the former genus should also be included.

C. occidens (Walcott.)
C. paralius (W. & W.)
C. cyrtolites (McC.)
C. fissurella (Hall.)
C. latus Keyes.
C. quincyensis (McC.)
C. acutirostris Hall.
C. spinigerus (Worth.)
C. formosus Keyes.
C. biserialis (Hall.)
C. equilaterus (Hall.)
C. infundibulum (M. & W.)
C. obliquus Keyes.
C. tribulosus (White.)
C. chesterensis (M. & W.)
C. parvus Swallow.

THE PERMO-CARBONIFEROUS OF GREENWOOD AND BUTLER COUNTIES, KANSAS.

L. C. Wooster, Eureka, Kan.

Greenwood and Butler counties are situated in the southeastern part of Kansas in the basin of the Arkansas river. The surface slopes southeast and is drained by three miniature



Section in Permo-Carboniferous and Lower Coal Measures.
Dip about 20 ft. to the mi., West.

river systems: Verdigris river on the east, Fall river in the middle, and Walnut river on the west. The watershed between Verdigris river and Fall river is low, the two streams uniting a short distance south of the district described; but Fall river and Walnut river are separated by a well defined ridge which extends seventy-five miles south to the state line and beyond into Indian Territory. The summit of this ridge seen in the section on the opposite page has an elevation six hundred feet greater than Fall river at Eureka and nearly four hundred feet greater than the Walnut at Eldorado. The great abundance of flint nodules in the limestones of this watershed has given it the name, Flint Ridge, or Flint Hills, and the terraced slope and somewhat notched crest make it one of the most conspicuous topographic features of southern Kansas, especially when approached from the east.

The major inequalities of surface produced by the varying resistances of the subjacent strata to stream erosion are represented fairly well in the section opposite, but the details of the erosion surface could be given only in a relief map and must therefore be left largely to the imagination of the reader. Remembering that the surface has been subject to rain and stream erosion for some millions of years and that there is no protecting glacial drift to disguise the inequalities of rock surface, he can readily see that the level surfaces are limited to river bottoms and to stretches of upland, preserved by an underlying stratum of resistant limestone.

Before describing the strata of Carboniferous rocks exposed to view in the banks of all these streams from their sources to their mouths, it will be of interest to study some of the peculiar erosive features of the river valleys.

Fall river valley has the steepest slope of any in southern Kansas, showing a fall of seven hundred feet in forty miles. This great descent gives the river, scarcely fifteen square feet in average section, a high erosive power which has caused it to cut very deeply into the alternating shales and limestones of the Carboniferous.

Rising in the northwestern part of Greenwood county in the Permian of the Flint Hills, Fall river takes a southeasterly course obliquely across the outcropping edges of Permo-Carboniferous strata and the Lower Coal Measures to its place of junction with the Verdigris, sixty miles away. For most of

this distance it is still cutting its channel deeper in the underlying rock; and the bordering first bottoms, averaging less than one-half mile in width, are receiving but slight additions of silt.

As might be supposed, such a stream does its chief work in times of flood. The average fall of the river and its tributaries exceeds twelve feet to the mile, the uplands and the slopes are destitute of forests, so the average rainfall of between thirty and thirty-five inches is quickly drawn into its channel and hurried onward to the Arkansas. The narrow border of timberland near the stream is insufficient to restrain the flood and a rise of twenty-five feet in a single day is not uncommon. This on-rushing torrent serves as a mighty plow and scraper combined, and every year it works a marked change in its rock-bottomed channel. The work of the river is aided by the varying character of the strata. The limestones and shales average only nine feet and twenty-five feet in thickness, respectively, and thus the river for its entire length shows a succession of cascades, rapids and deep quiet places. The bordering bluffs through the varying resistant power of the strata, show, through rain erosion, a similar succession of falls, being terraced to the top.

The broad valley of the Fall river, limited by bluffs frequently rising to a hight of one hundred and sixty feet, is wide enough for the Mississippi river, and seems at first thought to owe its existence to a river nearly as great. But the fact that Fall river and the neighboring streams hug, for the most part the southwestern side of their valleys, suggests a different explanation. The strata dip on the average about twenty feet to the mile, west by south, and consequently the rivers slide to the right side of their valleys and erode that border most readily and deeply. Deserted channels at higher levels are numerous on the other side of the valley, and give testimony in favor of this explanation.

Eureka lies in the abandoned portion of Fall river valley, and in some situations the village wells and cellars reveal some curious facts in its history. Two wells, sunk in alluvium three-fourths of a mile distant and seventy-five feet higher than the present channel of Fall river, brought to light portions of the skeletons of horses, at the depth of twenty-eight feet. A molar tooth in my possession evidently belongs to

the genus Equus. Whether these were the skeletons of the Spanish horse or of the ancient American genus, Equus, is a problem which awaits solution.

I have stated that there is no glacial drift in these counties to serve as a protective covering to the subjacent rocks. While this is true, it is also true that glacial drift is not absent. A polygonal bowlder of granite in the writer's possession, weighing four hundred pounds, was found near the summit of a high ridge in the eastern part of Greenwood county, nearly buried from sight in shallow soil and sub-soil. A bowlder of coarse granite weighing about forty pounds was discovered in a similar situation near Eureka on the south side of Fall river valley. A third bowlder is reported from the southern part of Greenwood county, near Fall river, and a pebble of serpentine was shown the writer which had been picked up in a creek valley a few miles east of Eureka. But these are all I have been able to see or learn about, and their rarity makes them objects of much interest. One hundred miles north near Lawrence and Topeka, drift hills with bowlders are not uncommon, and these bowlders may have been sent off in floes or small bergs from a glacier front in the Kaw valley. But as they were lodged on a surface that now has a hight of eleven hundred feet above the ocean, their presence suggests either a much less relative elevation at this latitude, or a great thickness of ice and depth of flood in the first glacial epoch.

THE CARBONIFEROUS STRATA.

The influence of the Carboniferous shales, limestones and sandstones in determining the topographic features of southern Kansas has been briefly considered in the preceding pages. A detailed description of the thousand and one strata exposed between Toronto and Eldorado would be out of place in the GEOLOGIST. So the remainder of this paper will be given to a study of the dominant features of the rocks and life.

Following a precedent established by Kansas geologists, the term, Lower Coal Measures, will be applied to strata designated Lower and Middle Coal Measures in Iowa and Nebraska; and Permo-Carboniferous, to the Upper Coal Measures and Permian of other regions.

St. John estimates the thickness of the Lower Coal Measures as limited above at 600 ft. and the Permo-Carboniferous at 2200 ft. Between these formations there is no percepti-

ble break but for reasons stated below the line of separation will be placed by the writer at the upper surface of the thick stratum of limestone,185 ft. thick, shown in the section at the head of this paper, penetrated by the boring at the village of Fall River south of Toronto. This is the thickest stratum of limestone of the entire Carboniferous formation and will thus constitute a useful horizon as a datum plane for the geologist. This limestone outcrops near the middle of Woodson and Wilson, the adjoining counties on the east and southeast, near the line Prof. St. John has fixed as the eastern boundary of the Permo-Carboniferous, possibly with this stratum in mind.

Between the base of the Permo-Carboniferous thus established and the summit of Flint Hills there intervene 1800 feet of shales, limestones and sandstones. The various outcrops show that the sandstones are limited to the lower 500 feet and the arenaceous shales to the lower 1,000 feet. The limestones and shales are evenly distributed between the base and the top.

One thin bed of coal lies about 400 feet from the base, another 700 feet, three about 850 feet and the highest bed, little more than a highly carbonaceous shale, about 1,300 feet.

The following tables will present other details of strata obtained from outcrops in the eastern, middle and western portions of the district.

	SHALES.		LIMESTONE.		SANDSTONE.	
	No. of Strata.	Average Thickness.	No. of Strata.	Average Thickness.	No. of Strata.	Average Thickness.
Near Toronto	4	18.5 feet	4	9.5 feet.	2	12.5 feet.
Eureka.......	5	25 "	6	5 "	1	10 "
Flint Hills....	28	10 "	29	4.5 "	0	0 "

Deep wells at Eureka, Fall River, Topeka and Emporia show similar sections. All were sunk with a churn drill ex-

	SHALES.		LIMESTONE.		SANDSTONE.	
	No. of Strata.	Average Thickness.	No. of Strata.	Average Thickness.	No. of Strata.	Average Thickness.
Eureka....... (504 ft. deep.)	15	17.7 ft.	15	10 ft.	1	74.75 ft.
Fall River,... (881 ft.)	7	43 "	9	50 "	2	47.5 "
Topeka,...... (1000 ft.)	27	22 "	30	9 "	1	3 "
Emporia...... (2000 ft.)	50	25 "	50	9.25 ft.	12	24 "

cept the well at Topeka which was bored with a diamond drill. The locations in the Permo-Carboniferous of the wells at Eureka and Fall River are shown in the section on page 10. The well at Topeka starts a little below the Eureka horizon and at Emporia a little above.

The records from the Eureka, Topeka and Emporia wells agree as closely as could be expected and correspond with the observed sections; but the Fall River record was not so carefully made, though the thicknesses of the strata are certainly somewhat greater in that part of the Permo-Carboniferous and Lower Coal Measures covered by the record. The Emporia well passed through three beds of coal in the first 500 feet and one bed in the last 500. This bed must belong to the Lower Measures.

In their lithological characteristics the lower shales are indistinguishable from the upper; and in all positions are nearly barren of fossils, except near the layers of limestone and in the calcareous or arenaceous portions.

The limestones of the Permo-Carboniferous are light to dark buff in color, usually very compact and well adapted for masonry. Outside the Flint Hills they are usually free from chert and very hard, almost glassy in their fracture. This is likewise true of many of the strata in the Flint Hills, but other strata are crowded with chert and are much softer under the hammer. Near the summit of the ridge and on the slopes towards Eldorado are the soft, light grey, almost white layers, so much prized for fronts and trimmings in the cities of Kansas. These upper beds, if any, belong to the Permian, and are persistent north and south across the state. Their thickness is unknown to the writer; but should the gypsiferous beds in the longitude of Wichita be placed in the Triassic, they, with the layers resting upon them, must exceed four hundred feet in thickness and not reach six hundred. This estimate is based upon the dip of the strata in the district covered by this paper, and on the belief that the line of junction with the Triassic was once near Wichita.

Of the 1800 feet of rock of our section in the Permo-Carboniferous, fully 1000 feet in round numbers is shale, 700 is limestone and 100 feet sandstone and argillaceous sandstone.

The sandstone strata are fine grained, and, as usual in the Carboniferous, hold many leaf and bark impressions. The

heavy bed at the base of our section out-cropping between Toronto and Yates Center, Woodson county, is much used for building purposes, as is also the thinner stratum above, outcropping west of Toronto; but the argillaceous beds of the middle part of the section, exposed at Eureka, are worthless except for building sand. The shallow water origin of these strata is shown by ripple marks and leaf impressions.

Some of the thinner beds of limestone are ripple-marked as well, but most of it is heavy bedded, or at least contains the remains of animals which frequent the deeper, purer waters, such as the crinoids whose stalks make a large percentage of the material of many of these layers, and many corals.

Since the deep sea then covering western Kansas and eastern Colorado would take to itself the debris of the western mountains, we must look for the source of the material of the sandstones and shales in the ancient mountains of Missouri, ranges of no mean extent and altitude, to furnish the thousands of cubic miles of sediments of the later Paleozoic formations of Missouri, Kansas and Nebraska.

So great was the diversity of conditions while these sediments were being deposited, so unequal and frequent were the oscillations of the crust of the earth over eastern Kansas, at least, that little reliance can be placed upon the thickness and lithological characters of the strata. It would seem that shale and limestone and even sandstone were being deposited at the same time even in an area not larger than a congressional township. The writer spent weeks, almost months, trying to trace a series of strata from bluff to bluff on the same side of Fall river and across the valley to the opposite side. Even coal beds were of little assistance for they varied greatly in thickness and extent. Fossils, the main reliance of the geologist, did not help for they varied in the same stratum and the same species occurred above and below, with fortunately, however, one exception. A layer of limestone was at last discovered containing Fusulina cylindrica var. robusta in great abundance. From this layer alone was it possible to prepare a section for Eureka and vicinity that would stand all tests. All field geologists will appreciate the joy attending its discovery.

Whether this layer with F. robusta extends more than three miles is not known by the writer; but he is confident that such horizons are rare, and that general truths gained from a study

of the whole body of strata are more useful over wide areas. These he has endeavored to give in the preceding pages.

LIFE.

Fossils are about equally abundant in the lower, middle and upper portions of the Permo-Carboniferous, and are especially numerous in the limestones, and the calcareous and arenaceous shales. Certain genera such as Productus, Athyris, Spirifer and Chonetes are represented by the same species throughout the formation and are therefore of little use in determining horizons. These widely distributed species are: Productus semireticulatus, P. nebrascensis, P. longispinus, P. prattenianus, Athyris subtilita, Spirifer cameratus, S. (Martina) planoconvexus, Chonetes granulifera and Fusulina cylindrica.

Those species which thus far have been found only in the lower (Neal) portion of the formation are: Myalina subquadrata, Pleurotomaria turbiniformis, Schizodus wheeleri, Syringopora multattenuata, and buckhorn coral, species and genus unknown.

In the middle (Eureka) portion: Several undetermined species of Macrocheilina and Allorisima; Petalodus destructor Pleurotomaria perhumerosa, P. inornata, Euomphalus rugosus, Eirsocirnus sp.? and two undetermined species of Sigillaria.

In the Lower Flint Hills (Reece): Pseudomonotis hawni var. sinuata, Aviculopecten occidentalis, Meekella striato-costata, and Spiriferina kentuckensis.

In the Upper Flint Hills (Permian): Chænomya leavenworthensis, Pleurophorus subcuneatus, Myalina perattenuata and a Nautilus sp.?

The above determinations rest solely upon the writer's judgment. A more experienced palaeontologist would probably modify the list. The writer used Meek's Palaeontology of eastern Nebraska, vol. II of the Palaeontology of Illinois, and Dana's Manual, principally the first, in classifying his collections.

Some general statements respecting the life of the Permo-Carboniferous will probably be as helpful to the geologist as the above lists: Cup corals are much more abundant in the lower than in the upper half of the formation. One layer of limestone near Neal is an intertwined mass of Campophyllum torquium. Incrusting corals are everywhere common.

Crinoid columns are very abundant in the lower and middle

shales and limestones. Heads are not common and with the exception of Zeacrinus mucrospinus in the lower and middle strata, only two have been discovered. One of these, found at Neal, Zeacrinus, measures four inches from the base to the tips of the arms, and another at Eureka, an Eirsocrinus, is about half as long.

Sea urchins are represented by plates and spines in all parts of the formation.

Among brachiopods, Spirifer cameratus and Hemipronites crassus are remarkable for their wide range in size and distribution, and Productus semireticulatus for its great size and wide range. The last with P. nebrascensis is very common in the chert at the summit of the Flint Hills.

Lamellibranchs are widely distributed and belong quite largely to the order, Asiphonia. The characteristic forms have been mentioned above; but many collected are as yet undetermined.

Gasteropods have likewise a wide range, and many forms remain unclassified. A single layer of limestone at Eureka has yielded the major part of the collection. One, a Murchisonia-like gasteropod, measures three and one-half inches from the base to the apex and revolves eight times in the same disance. The Macrocheilinæ in the same layer rank next in size.

Chambered shells and trilobites have thus far been found only in the middle and upper strata.

Sharks teeth of the genus Petalodus occur in the Eureka horizon, and labyrinthodont foot-prints are found in layers of limestone a short distance above the same horizon.

Unclassified species of sea weeds, Calamites, ferns and Sigillaria have been collected at nearly all horizons to the base of the Flint Hills, not above.

The writer has been especially interested in the fact that forms that are to become extinct at the close of the Permian show no diminution in numbers in the highest strata examined. They seem to await the great change in their environment as their final summons to give up their long struggle for existence, and not to die out from the infirmities attending old age.

ON THE CONTACT OF THE HURONIAN AND LAURENTIAN ROCKS NORTH OF LAKE HURON.

By ALFRED E. BARLOW, M. A., Ottawa.

Read before the Logan Club, Ottawa, February 27th, 1890.

In this paper the writer proposes to bring forward some observations on the nature of the contact between the typical Huronian rocks of lake Huron and the Laurentian gneisses, which, it is thought, have an important bearing on the question of the origin and relative age of the latter. During the past five years he has had many opportunities, first as assistant to Dr. A. C. Lawson in the lake of the Woods and Rainy lake regions, and latterly as assistant to Dr. R. Bell in the country north of lake Huron, of becoming familiar with the phenomena of Archean geology and of studying particularly the conditions of contact where the Laurentian comes against the other rock formations of the Archean complex.

The Huronian area to the north of lake Huron is made up of a series of quartzites, graywackes, slate conglomerates, clay slates, hydro-mica, chloritic, epidotic and hornblendic schists, diabase and cherty limestones.

The majority of the clay slates have the appearance of being very little altered except in contact with the diabase and other igneous rocks and present in great part the same appearance as when hardened from the original soft sediments. The quartzites, graywackes and slate conglomerates have all been hardened and altered by the deposition of silicious matter between the component grains, and near the gneiss the two former species are altered into quartzose mica schists. In the neighborhood of diabase masses the slates and limestones are hardened and traversed by reticulating veins of secondary quartz, while the quartzites near igneous masses become more indurated and present veins of secondary quartz running parallel with the bedding, so that it is likely that the eruptive material has been the source of the heated solutions of silica. The Laurentian formation to the north of lake Huron is represented solely by orthoclase gneiss, a rock which may be described as essentially a crystalline admixture of feldspar, quartz and hornblende or mica, although in many cases both these last named minerals are present in the same rock mass. It is distinguished from granite only by its foliated texture, a structure produced by the parallel distribution of the compo-

nent crystals or the alternation of lighter and darker bands according to the prevalence of the feldspar and quartz or hornblende and mica. Frequently this foliation is quite distinct, though sometimes it is obscure and occasionally it can not be detected at all, the rock then being indistinguishable from ordinary eruptive granite.

Messrs. Logan and Murray, although they carefully examined and mapped out the distribution of the different members of the Huronian system, almost ignored its contact with the Laurentian, and it is only of late years that attention has been directed to the contact as a means of ascertaining the relative ages of the two systems. In the absence of all fossil remains this is the only criterion to determine the age of Laurentian gneiss in regard to the Huronian.

Dr. Robert Bell, in his report[1] on the geology of the neighborhood of the village of Shiboananing (Killarney) says: "The village itself stands upon red syenitic granite, which, "except at the sides, has a massive homogeneous structure, "but in a few instances a single reddish or yellowish green "shaly streak an inch or two in thickness was observed running "in a northeasterly direction. Towards each side the grain of "the rock begins to assume a sort of parallelism or a gneissoid "structure." The junction between this and the Huronian quartzite and hornblende schists is seen at a rocky island in a cove about a mile north of the western end of "the passage" on the north side of which the village is built. "The granite is flanked by a stratified rock of a reddish gray color consisting of a fine grained crystalline mixture of feldspar and quartz." Both rocks have approximately the same northeasterly strike, but while the Huronian beds are about vertical the granitoid gneiss dips southeast $\llcorner$ 50°. Dr. Bell refers this granitoid gneiss to the Huronian rather than the Laurentian although he gives no reason for so doing. The coincidence in direction of the "streaks" in the midst of the granite itself as well as the more perfect development of the lamination near the junction with the Huronian schists are characteristic features of obscure or non-foliated gneissic areas.

From Killarney the line of junction strikes in a northeasterly direction for about sixteen miles, crossing the eastern boundaries of the townships of Goschen and Carlyle (Salter's

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[1] See Report Geological Survey of Canada, 1876-1877, page 208.

meridian line) about six miles south of lake Panache, although the limit of the Huronian in this direction has not been ascertained with precision. In this vicinity it must turn to a more northerly direction for it passes about a mile to the east of lake Panache with a strike of N. 25° E.

The shores and islands of the eastern portions of lake Panache are occupied by a granular quartzite of varying shades of gray; mica in the form of minute desseminated scales and also feldspar are usually present in small quantities. About three miles from the contact with the gneiss, these Huronian quartzites show signs of great disturbance and the strike which has hitherto been nearly east and west turns abruptly to the southeast, this change being still farther continued till the strata just southeast of the lake have assumed a southeasterly strike, thus corresponding with the line of outcrop of the gneiss in this direction. A little to the north of this eastern end of lake Panache and emptying into it, is Gabodin lake, about two miles in length. At the western end or outlet of this lake micaceous quartzites were noticed with a strike of N. 75° E. which curves around quickly, for on the islands in the eastern part of the lake quartzose mica-schists were seen striking N. 15° E., these rocks being thus conformable with the line of outcrop of the gneiss in its northerly continuation. The rapid changes in the strike of the quartzites is accompanied by a very marked alteration in the character of the rocks themselves. The granular quartzites and sandstones which have previously shown no further signs of alteration than a hardening consequent on the interstitial deposition of silicious matter are now metamorphosed into very typical quartzose mica schists. The change is gradual but marked and extends to a distance of three miles from the line of junction.

The planes of bedding of the Huronian mica schists are parallel to the lamination of the gneiss. Both rocks have a strike N. 25° E. and a dip of S. 55° E. ∟ 75°, the mica schists, however, dipping into or under the gneiss. Penetrating the schists are lenticular sheets and patches of gneissic material of character and composition similar to the great mass of the gneiss in the immediate vicinity, to which they may often be continuously and directly traced. These intrusions of gneiss have disposed themselves usually in a direction parallel to the

bedding of the schists, thus showing the coincidence of the lines of least resistance with the lamination of the schists.

The eruptive nature of these gneissic patches and sheets is quite evident from even a cursory examination of the relations of the two rocks "in situ" for the foliation of the gneiss composing these intrusions is parallel to the walls of the fissures, even when these fissures cross the strike of the schists. This also demonstrates that gneissic lamination is caused by the flow of the rock while viscid under differential pressures. Angular fragments of the Huronian mica-schists are included in the gneiss, the foliation of the latter conforming roughly with the irregular outlines of the fragments. The flow structure thus produced is always very marked. We have then the three criteria by which the presence of an eruptive mass is ascertained: 1st, the penetration of the sedimentary strata by dykes of the irruptive matter; 2nd, the occurrence of broken fragments of these same beds in the irruptive mass itself, and 3rd, the metamorphism or alteration of the stratified rocks along the line of junction. Evidence is also furnished of the irruptive character of this gneiss by the abrupt changes in the strike of the mica schists in the vicinity of the line of outcrop of the gneiss.

The line of junction was next seen on the western shore of Wavy lake about six miles in a direction N. 16° E. from the place where it was examined east of lake Panache. Although it has not been thoroughly explored through the intervening space, the boundary can be laid down with a very close approximation to the truth from a knowledge of the strike of the gneiss in the neighborhood; for it has been noticed that the direction of the line of demarcation depends not on the strike of the Huronian schists or quartzites, but on the foliation of the gneiss, whose line of outcrop is always parallel to the gneissic lamination in the immediate vicinity. In the southern part of Wavy lake the gneissic foliation has a northeasterly trend, which in coming north gradually curves around to an almost easterly direction. In the northern portion of the lake the strike bends around very abruptly from a northeast to a southeast direction and the change is further continued till in the eastern part of the lake the lamination of these two areas of gneiss converges in a common strike of N. 70° E. A funnel-shaped trough is thus formed in the western portion

of the lake, which is occupied by a tongue of highly inclined Huronian quartzites. At the southern edge of this trough the quartzites abut directly on the gneiss as on an irruptive mass, the strike of the former being N. 65° W. Dip S. 25° W. ∟ 50 while the foliation of the gneiss is N. E. Dip S. E. ∟ 75°.

At the northern edge of the trough the stratification of the quartzites corresponds in direction with the lamination of the gneiss. Both rocks strike S. 38° E. Although their declination is in opposite directions, the quartzites dipping S. 52° W. ∟ 80°. while the gneiss dips N. 52° E. ∟ 80.

The quartzites near the line of junction on Wavy lake are not so highly altered as on lake Panache, yet the proportion of mica in these rocks is seen to increase as the gneiss is approached. Where they abut on the gneiss, the quartzites are very much broken up and a jointed structure developed nearly parallel in direction with the line of contact. At the eastern end of the lake where the lamination of the northern and southern areas of gneiss converge in a common strike, angular fragments of various sizes of the Huronian micaceous quartzites were noticed embedded in the gneiss, the foliation of the latter flowing around the irregular outline of these fragments.

From Wavy lake the line of demarcation curves around very quickly from northwest to northeast and was next seen on the north shore of Chief's lake, on the south line of the township of Broder (Salter's base line) three and a half miles east of Long lake. Throughout this distance of nearly six miles, the general strike is northeast. Mr. Alex. Murray, who made an examination of the rocks exposed on Salter's base line simply describes the boundary here as a junction between "red gneiss" and "greenish mica slate."

The line from this point strikes due north into the township of Broder for about a mile when it bends around to the northeast for half a mile and then to N. 78° E. which general strike it maintains till the eastern line of Broder is reached.

Where this last abrupt change in the line of junction takes place the Huronian rocks with a strike of N. 75° E. and dip S. 15° E. ∟ 65° abut on the gneiss whose lamination has a direction of N. 40° E. and dip S. 50° E. ∟ 68°. Throughout the remaining part of the township of Broder, however, the micaceous slates and quartzites have approximately the same

strike and dip as the gneiss. The gneiss is always superimposed on the sedimentary strata and both rocks dip in a southerly direction at angles varying from 65°-70°.

Near the line of junction the siliceous slates and quartzites become highly schistose and micaceous and show signs of having been subjected to great pressure. Angular pieces of the schistose rocks are included in the gneiss, especially near the curve in the line of junction, while intrusions of gneiss were seen at several places penetrating the stratified rocks. In one instance a lenticular mass of distinctly laminated micaceous gneiss was seen intruded through the schists parallel to their bedding at a distance of three hundred yards from the line of contact. Besides these gneissic intrusions there are irregularly shaped fissures,running transversely to the strike of the schists and filled with coarsely crystalline feldspar and quartz. In the larger portions of these veins, the feldspar and quartz are present in about equal proportion, but where they begin to thin out, quartz seems to be the main, and, in some cases, the only constituent. These pegmatitic apophyses are evidently portions of the adjacent gneiss which have been injected through the schists and crystallized in the presence of heated vapours. A large pegmatite vein of this sort was noticed on the line between Broder and Dill, extending across the strike of the schists for a distance of half a mile from their contact with the gneiss. Through the township of Dill the boundary has not been examined in detail, but it follows in general a northeasterly course for about five miles when there is another abrupt turn to the north, and the junction was again seen exposed to the west of a small lake which flows into the Wahnapitae river four miles below Wahnapitae Station on the Canadian Pacific railway. The whole line of contact from Wavy lake to this point follows very closely the trend of the chain of lakes which form "The Whitefish River route." On the portage leading westward from this small lake the Huronian slates and quartzites, with a strike varying from east to northeast, are interrupted by the gneiss, whose foliation has a northerly direction. The siliceous slates and quartzites have been metamorphosed even at a distance of two miles from the contact. Finally crystalline feldspathic intrusions as well as more coarsely crystalline apophyses of pegmatite penetrate the sedimentary strata while the gneiss near the line of junction

is rendered more schistose or slaty by the incorporation of detached fragments of slate and quartzite elongated or flattened in the direction of the gneissic foliation.

Continuing still further northeast the boundary strikes the Wahnapitae river just below the Canadian Pacific railway bridge. The actual contact is not seen and the intervening space of one hundred and fifty yards between exposures of the two rocks is occupied by the river and a grassy flat. On the west side of the bridge are light greenish gray feldspathic quartzites with some thin interlaminated bands of darker colored sandy shale which have a strike of N. 65° E. and dip N. 25° W. $\angle$ 60°-70°. On the opposite bank of the river and near the railway station a dark gray, evenly laminated micaceous gneiss was noticed striking N 67° E. and dipping S. 23° E. $\angle$ 60.° Ruby colored garnets, arranged parallel to the foliation, are exceedingly numerous, the crystals frequently measuring from a quarter to half an inch in diameter.

The line of separation is occupied by the bed of the stream for a short distance when it again strikes inland, running parallel to the general course of the river. Through this distance of nearly six miles the contact is generally half a mile southeast of the river. The gneiss dips in a southeasterly direction at high angles, while the Huronian rocks with the same strike are nearly if not quite vertical. Apophyses of pegmatite are very often seen penetrating the silicious slates and quartzites which near the line of junction are altered into mica-schists. For nearly two miles further the contact is again concealed by the bed of the stream; but from this point it strikes across the country in a direction N. 60° E. for sixteen miles and was next seen by Mr. Murray crossing the Sturgeon river two miles below its confluence with the Maskinongé river. Nothing very definite, however, was ascertained regarding the relations of the two rocks at this place. Continuing on the same general course for twenty miles the line of division strikes the southern end of Cross lake. Here the Huronian slate conglomerate underlies the gneiss with perfect conformity, both rocks dipping S. 35° E. $\angle$ 56°. The slate conglomerate has very evidently been disturbed and altered near the line of contact and where the two rocks are in immediate juxtaposition a very perfect set of cleavage planes were noticed in the conglomerate dipping N. 50° E. $\angle$ 73°. At first these were mis-

taken for the planes of bedding but a more careful examination revealed their true character. Further to the northeast on lake Temiscaming the syenitic gneiss rests conformably on the Huronian strata, both rocks dipping to the southeast at high angles.[2]

Mr. Walter McQuat in his report of the Temiscaming region gives a very detailed description of the junction as exposed on that part of the Ottawa river locally known as "The Quinze." He mentions especially the occurrence near the contact of lenticular masses of a gneissic character in the Huronian hornblende schists which have a general direction corresponding with the bedding. In addition he notes the intrusion through the Huronian at a considerable distance from the line of junction of a light gray granitic gneiss, whose foliation is parallel to the stratification of the adjacent schists. This lenticular irruptive mass measures six hundred yards long by one hundred wide and the direction of the longer axis corresponds with the strike of the schists. As the stream is ascended and the great mass of the gneiss approached the sedimentary strata show signs of great alteration and hornblendic, chloritic and steatitic schists occupy the upper portion of the river. At the junction the Huronian schists are seen to rest conformably on the syenitic gneiss. Further to the north where Mr. McQuat made a somewhat hurried examination the Huronian rocks everywhere near the contact with the gneiss, exhibited abundant signs of disturbance and alteration consequent on the irruption of the gneiss. The same geologist in his exploration of the Blanche river which flows into the northern end of lake Temiscaming, notices the occurrence of two areas of gneiss separated from one another and apparently completely surrounded by Huronian schists. The southern area is about ten miles across but the limits of the northern area exposed on the shores of Round lake at the head of this stream were not ascertained. On the southeast as well as on the northwest side of the southern area, the gneiss rests conformably on the chloritic, micaceous and hornblendic schists, occupying apparently a synclinal basin in these schists. At the southeastern edge of the northern area the schists dip away from the gneiss. Although Mr. McQuat in his printed report refers to the northern area as an intrusive mass of syenite, he colors

[2]See Report Geol. Survey Canada 1872-73.

it on his accompanying manuscript map as Laurentian gneiss, evidently deeming it of similar character and origin. The Huronian rocks in this district form a belt composed chiefly of quartzites, slates and conglomerates, which, starting from the northern shores of lake Huron extend in a northeasterly direction. The belt varies in breadth from about twenty-five miles in the vicinity of lake Huron to nearly one hundred miles in the Temagami region. At various places isolated areas of granitoid gneiss protrude through these sedimentary strata, the latter curving around the irruptive masses and conforming in general with their line of outcrop. An area of this kind, four or five miles in width, occupies the north shore of lake Huron, extending along the coast from Blind river to the vicinity of the mouth of the Thessalon. Another area was noticed north of Whitefish station on the "Soo" branch of the Canadian Pacific railway.

Dr. Bell has remarked the occurrence of two of these bosses on the Montreal river which may possibly be connected with the two areas seen by Mr. McQuat on the Blanche river. A boss of distinctly foliated flesh-red hornblendic gneiss occupies a portion of the shores of Carrying, McLean and Anima-nipissing lakes, which lie between lake Temagami and the Montreal river. The thinly bedded slate conglomerate through which this mass has been intruded is everywhere altered in contact with the gneiss. Near the line of junction the Huronian strata rest unconformably on the upturned edges of the gneiss. On Anima-nipissing lake where the immediate contact was examined the slate conglomerate inclines N. 50° W. $\angle$ 50° while the gneiss dips S. 85° E. $\angle$ 70°. Along the line of junction the slate conglomerate dips off the irruptive mass at high angles (50°-60°) while only a short distance away the declination is at a comparatively low angle (15°-20°).

On the western side of Wahnapitæ lake are exposures of a pale flesh-red hornblendic gneiss whose contact with the surrounding Huronian quartzite and diabase indicates its intrusive nature. The characteristic brecciated junction is everywhere displayed where the two rocks are seen in juxtaposition. Bands of gneiss penetrate the quartzite and greenstone while angular fragments of the two latter rock species are included in the gneiss which is distinctly foliated and indistinguishable from what is usually called Laurentian. This gneissic area is

probably continuous with the one to the southwest in the township of Blezard and may even be connected with the small exposure of finely crystalline irruptive syenitic gneiss seen to the southeast of the Murray mine four miles northwest of Sudbury.

The line of demarcation is very seldom a simple plane of division, the breccia present along the line of junction frequently covering a considerable space. It is therefore often impossible to draw an accurate line of division between these two rocks unless we assume that such a line should be placed where the two rocks are present in about equal proportion. The general correspondence of the gneissic intrusion with the stratification of the enclosing schists and the frequent lenticular outline and parallel disposition of the detached schistose fragments in the gneiss often resemble at first sight an alternating sequence of transitional beds. Again the crystalline condition of the Huronian feldspathic and micaceous quartzites near the line of contact, which frequently resemble in character and composition the more evenly laminated gneisses has been referred to as evidence of such a transition. But even in such a case the bedded character of the Huronian is in strongly marked contrast to the granitic aspect of the gneiss.

In conclusion then, the following facts seem to prove beyond a doubt the irruptive nature of Laurentian gneiss and its magmatic condition at a time subsequent to the petrifaction of the Huronian sediments. 1. The diverse stratigraphical relations of the two rocks along their line of junction. More frequently perhaps the Huronian strata dip into or under the gneiss, although very often this position is reversed and the Huronian beds are seen superimposed on the gneiss with perfect conformity. In many instances the two rocks occupy vertical positions side by side and occasionally the gneiss has been observed dipping away from vertical Huronian strata. Huronian rocks have also been seen resting unconformably on the upturned edges of Laurentian gneiss. Sometimes where the sinuosities of the line of outcrop of the gneiss were too abrupt to be followed by the stratified Huronian, the latter rocks have abutted on the gneiss as on an irruptive mass. These different phenomena can all be readily and naturally explained by the irruption of the gneiss, while on the hypothesis

of an aqueous origin such explanation must be difficult and unsatisfactory. 2d. The alteration of the sedimentary rocks along the line of junction is a feature that has been invariably noticed where the contact has been carefully examined. 3rd. The inclusion of angular fragments in the mass of the gneiss which are clearly referable to the adjacent sedimentary strata. Near the line of junction these detached pieces have a clear and sharp outline while further in the mass where they have undergone partial fusion and absorption their outlines are blurred and indistinct. 4th. The occurrence of gneissic intrusions as well as more coarsely crystalline apophyses of pegmatite, both interlaminated with and transverse to the bedding of the Huronian rocks. These intrusions are distinctly irruptive and can often be directly traced to their source in the larger area of gneiss in the vicinity. 5th The absence of limestones, slates or quartzites or in fact any species of rock indicative of ordinary sedimentation. The crystalline limestones so far observed in the Laurentian in the lake Huron region are simply veins of calcite while the quartzites and mica schists sometimes seen interlaminated with the gneiss, are only quartzose and micaceous conditions of the more common feldspathic gneiss. 6th. The general character of the rock itself which in appearance and behavior has far more resemblance to an ordinary irruptive granite with a foliated texture, than an altered sedimentary rock. Sir. W. E. Logan himself in his notes of its occurrence on lake Temiscaming, invariably refers to it as "gneissoid syenite." The Huronian system therefore may be regarded as the oldest series of sedimentary strata of which we have at present any knowledge in this region. The original sediments must have been laid down on a firm floor whose composition judging by the character of the Huronian rocks must have been closely analogous to granite. The slates, conglomerates, quartzites and greywackes have all been derived from the waste of older feldspathic material. The laminated pebbles in the slate conglomerates indicate that this feldspathic floor had at least in places a foliated or gneissic structure. It was doubtless the fusion and subsequent recrystallization of this gneissic or granitic floor that gave rise to the Laurentian gneiss. The immense pressure exerted by the weight of the super-incumbeut mass of Huronian strata, and the crumpling, folding and fracturing of the comparative-

ly thin and weak crust consequent on the earth's secular refrigeration would all tend to mark the lower portions of the Huronian beneath the line of fusion,and as this fusion continued a large part of the stratified rocks was assimilated into the mass of the gneiss. This granitic fusion or alteration must have taken place at a great depth below the earth's present surface and subsequent upheaval and denundation have now exposed it. Strong evidence has been secured from frequent observations of the strike of the gneiss through the lake Huron country that a great part if not all of the region characterized by the presence of this rock is made up of huge circular or irregularly oval shaped concentric areas which anastomose with one another. This concentric arrangement of the gneissic foliation seems to indicate that the forces of upheaval in the gneiss have acted from certain centres. These observations and conclusions indicate that the typical Huronian bears a relation to the Laurentian precisely similar to that which has been established in the country northwest of lake Superior for the Keewatin and Coutchiching groups of rocks by Dr. A. C. Lawson.

Dr. A. C. Lawson very kindly undertook the examination under the microscope of seven thin sections of both rocks to show some of the contact phenomena, and below will be found the result of his investigations.

Slide No. 1. North shore of Archie bay, lake Panache, four miles west of the contact.

This rock may be regarded as a typical specimen of the less altered quartzite and a thin slice of it was examined under the microscope to show its relations with the more altered micaceous quartzite near the line of the junction. "A fine grained, light yellowish gray quartzite rust "stained in places; under the microscope it is seen to be a crushed "quartz-sandstone. A cataclastic condition is seen to have been induced "upon the original epiclastic grains of quartz; wavy extinction is com- "mon. There is a rude parallel arrangement of the quartz grains in "long areas and between the constituent grains is a fine cement "which is largely made up of a felt work of muscovite. In some por- "tions of the slide this felt work of muscovite is mixed with clastic "grains of quartz and forms a base in which the larger clastic grains "are imbedded. Besides quartz there is present a notable proportion "of fragments of feldspar."

"Slide No. 2. In contact with the gneiss east of lake Panache. A "light gray, fine textured, somewhat micaceous quartzite with occas- "ional "sheen surfaces" along shear planes. Under the microscope the "rock is seen to be an aggregate of subangular or rounded quartz grains "with a subordinate proportion of feldspar grains, most of the latter "being quite fresh and showing the multiple twinning of plagioclase. "Some of this plagioclase is clearly in original clastic grains but some "appears to be secondary interstitial growth. Scattered throughout

"the slide are numerous scales of brown biotite and a less proportion "of muscovite. Most of these mica scales have a parallel arrangement "but some are seen to have been developed in the curved lines or areas "between the original clastic grains. Some of the quartz grains show "evidence of pressure in the optical tension which they manifest under "crossed nicols. Inclusions are not abundant in the quartz."

"Slide No. 3. In contact with the gneiss east of lake Panache. A "silvery micaceous, very quartzose schist, somewhat rusted, and with "strongly micaceous sheen surfaces. Under the microscope the rock "is seen to be composed essentially of quartz and muscovite. There "is a well marked parallelism in the arrangement of the muscovite "and the quartz shows distinct cataclastic structure, wavy extinction, "arrangement in parallel areas and other crushed phenomena. Evi-"dently an altered sandstone."

"Slide No. 4. Contact east of lake Panache. The hand specimen "before sliced showed two small bands of granitoid gneiss irruptive "through it. "Dark greenish gray fine-grained quartzite traversed by a "small stringer, three-quarters of an inch wide of rather coarse flesh "red granite. Under the microscope the quartzite is a typical epi-"clastic rock presenting no strong evidence of deformation by pressure. "It consists of a heterogeneous aggregate of clastic grains of quartz and "feldspar, much of the latter being plagioclase. In sections the shape "of these grains is rounded, sub-angular or sometimes angular. The "larger grains are imbedded in a base composed of much smaller grains "of the same materials but intimately mixed with a green chloritic sub-"stance which gives its color to the rock. The section crosses the con-"tact of the granite stringer and the quartzite. The contact between "the two is sharp but ragged and portions of the clastic rock are seen "to have been incorporated in the granite. The granite itself is a "coarse angular aggregate of orthoclase and quartz, with extremely "little of the ferro-magnesian constituent. There is a certain amount "of finer base in the granite of which it is difficult to say whether it is "simply a later and more rapid consolidation of the magma about the "larger constituents or whether it is a portion of the clastic rock which "has been incorporated without fusion in the granite."

Slide No. 5. Laurentian gneiss in contact with Huronian micaceous quartzite, north shore of Wavy lake. "A reddish highly feldspathic "granite with occasional shear planes traversing it. Under the mi-"croscope the rock is a granular aggregate of orthoclase, quartz, "plagioclase and biotite in which crush phenomena are to a "limited extent apparent. The orthoclase is very much kaolinized "in its central portion but quite fresh in the peripheral zone. The "plagioclase is as a rule fresh. The biotite is very sparingly represent-"ed and is almost entirely altered to chlorite. There is present also a "little brown iron oxide. The effects of secondary pressure are seen "on the occasional dislocation of the plagioclase crystals and in cata-"clastic structure which has to a limited extent been developed in por-"tions of the sections."

Slide No. 6. Township of Broder, Concession III. Line between "lots 4 and 5, 350 yards north of the contact with the gneiss. "A gray "moderately fine textured schist, spotted with scales of brown mica "and having uneven or lumpy cleavage surfaces, with marked silvery "gloss. Under the microscope the clastic character of the rock is ap-"parent, it being composed of grains of quartz and feldspar chiefly. "Throughout this clastic aggregate there have been developed numer-"erous plates of brown mica and some of muscovite nearly all in paral-"lel position. Scattered throughout the slide are nests of separated or "closely aggregated grains of a light yellow pleochroic mineral proba-"bly epidote. The separate grains of epidote in each nest have for the

"most part all a common orientation and extinguish together. None "present crystalographic boundaries nor distinct cleavages. There is "a considerable proportion of black opaque material scattered through "the section—probably magnatite."

Slide No 7. Township of Broder, Concession III. Line between lots 4 and 5—at the contact. "A pinkish to yellowish gray medium tex-"tured biotite granitoid gneiss, with a portion of a very fine textured "greenish gray schist partly adhering and partly enclosed in the gran-"ite on one side of the specimen. The thin section examined is across "the contact of the granite gneiss and the schist. In the section the "two rocks are very distinct and the contact while fairly sharp shows "portions of the schists included within the granite. The granite is a "granular aggregate of orthoclase, microcline, plagioclase, quartz, bio-"tite and muscovite. Some of the orthoclase shows a zonal structure, "the interior idiomorphic portions being more decomposed than the "outer zone whose form is allotriomorphic. A colorless mineral with "strongly marked relief, probably garnet, was also observed without "crystalline boundaries. Some small shreds of chlorite arising ap-"parently from the decomposition of the biotite, are also found scat-"tered through the granite. There is present in association the chlo-"ritized biotite, some magnitite and also some opaque granular dust, "probably also magnitite. Apatite occurs sparingly in slender needles "and in stout oval bodies. In the structure of the rock there are some "slight evidences of pressure seen in the occasional dislocation of a "crystal of plagioclase but there is neither shearing or cataclastic "structure. The schist in contact with this granite is profoundly "sheared and it only requires an inspection of the slide to see that the "shearing was affected before the magma from which the granite has "crystallized was brought in contact with the schist. The schist is "composed essentially of quartz and muscovite and these minerals "rearranged in parallel thinly lenticular areas which wedge into one "another. The optical tension of the quartz lenses is very constant. "The cataclastic structure of the quartz is pronounced. The general "aspect of the schist is that of a streaky rhyolite.

ARTESIAN WATER FROM THE DRIFT.

By CHAS. W. ROLFE, Urbana, Ill.

The presence, in the drift, of water-bearing veins under sufficient head to cause them to flow at the surface when tapped is not a very uncommon occurrence, but the district about to be described is, I think, remarkable for its size, and the ease with which flowing wells can be obtained over a large part of its area. This fact, and the many misconceptions of its structure as shown by the theories advanced to account for its water supply, have led me to think that a brief study of its characteristics would be acceptable as an aid in interpreting similar phenomena elsewhere.

The district lies on the eastern side of the state of Illinois, about sixty miles south of Chicago, and is roughly covered by Iroquois county, although it reaches over into the contiguous

portions of Kankakee, Champaign and Vermillion counties. Its eastern boundary seems to agree essentially with the state line, and its western with the eastern side of Ford county. The area is approximately 1200 square miles.

Its general surface may be described as a level prairie sloping gently to the north with an average inclination of about three feet to the mile, and diversified here and there by ridges and groups of low hills evidently left as moraines by the retreating Lake Michigan glacier. The southernmost of these runs eastward from Rantoul, following closely the line of the narrow guage railroad.

The entire area is covered by a mass of drift varying in thickness from seventeen feet, seven miles north of St. Anne in Kankakee county, to more than three hundred feet in central and southern Iroquois county.

Records of borings and cuts, show that this drift is made up of a tough blue clay, which encloses here and there elongated masses of sand and gravel varying from a few inches to more than twenty feet in thickness. These sand beds are always surrounded by a layer of closer grained, more impervious clay called hardpan by the well borers, and are always water bearing.

In the more elevated portions of the area, no flowing wells, so far as I am able to find, have been obtained, but between and around these at lower levels many wells have been struck from which water can be made to flow above the surface to a hight which varies from a few inches to four feet, the usual limit. In two instances only that have come to my knowledge did the water rise to the hight of ten feet. One of these was at LaHogue near the Ford county line and the other that east of Penfield just over in Vermillion county.

The depth of the wells varies from five feet to over two hundred and seems to be entirely independent of surface elevation. At LaHogue the well mentioned above is ninety feet deep, while at Gilman, whose elevation is fifteen feet less, the wells are usually from one hundred to one hundred and twenty feet, and a few miles farther east, where the surface is twelve feet lower still, they are only sixty feet deep. Then again at Buckley, twelve miles south of Gilman and forty-five feet higher, the usual depth is only five feet. As a further illustration, two wells were bored not far from Gilman, one of which reached

flowing water at the depth of thirty-seven feet, while the other, only a few rods distant and on about the same level, only found it at a depth of one hundred and eighteen.

At several places in the county, there appear to be two artesian horizons, but on the other hand the presence of a flowing well is nowhere a guaranty that another can be struck even at a few rods distance. Dry holes or "pump wells" are common result of borings in all parts of the county. A farmer near Penfield in Champaign county has five flowing wells, in one of which water was found at forty-five feet, and again at one hundred and fifty-eight, the water rising about two feet above the surface each time, while a number of his neighbors have bored with no success.

Several theories have been advanced to account for the presence of artesian water in this district, of which I shall only notice three. The first, and perhaps the most plausible is that the prolongation of the Oregon-LaSalle fault permits the rise of water from the St. Peter sandstone. In answer I would call attention to the fact that the fault disappears a few miles south of LaSalle and its further course, or continuance even, is purely hypothetical; that the point near LaSalle at which this sandstone outcrops is several feet below the lowest point in this district; that south south-east of the outcrop this formation dips rapidly under the great synclinal of central and south-eastern Illinois. The deep borings at Chatsworth and Paxton both made at some distance from the supposed course of the fault on its upthrow side failing to disclose its presence at a depth exceeding one thousand feet, and that even if the St. Peter sandstone was so situated as to make it a possible source of water the character of the drift material and the peculiar distribution of its water-bearing pockets would make it impossible that they could draw their water from it.

A second theory looks on lake Michigan as a probable source of the water, but the entire area lies from sixty to two hundred feet above the level of the lake.

A like answer can be given to the theory that regards the Kankakee swamps as the source.

The facts given above would seem to warrant the following conclusions:

The Lake Michigan glacier in its backward and forward movements, caused by alternating series of cold and warm

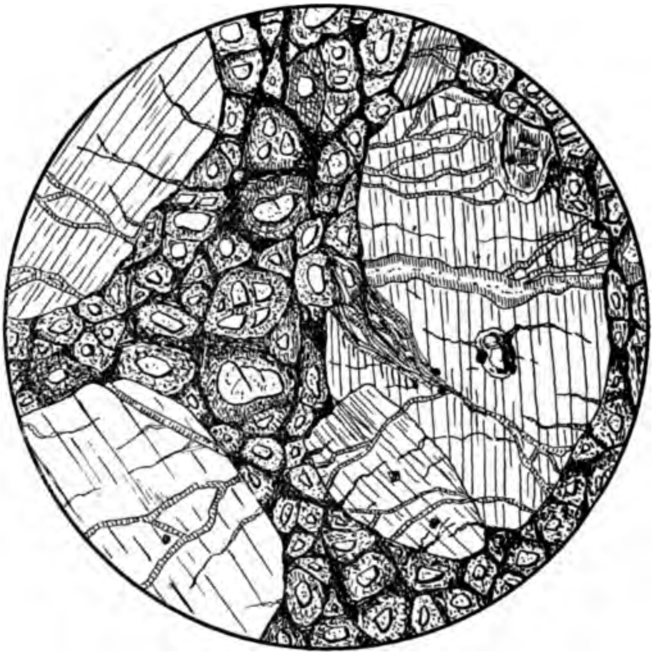

FIG. 1.
PORPHYRITIC LHERZOLITE.

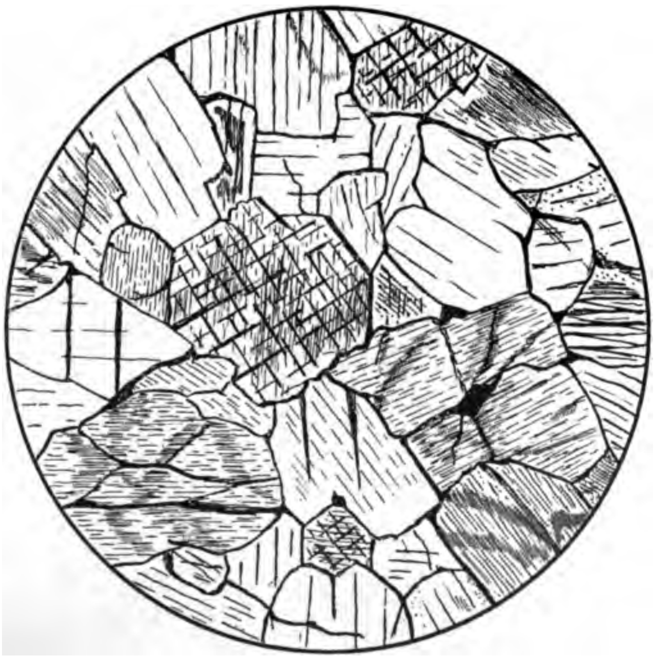

FIG. 2.—WEBSTERITE.

seasons, built up as its ground moraine the immense mass of drift which, as we have seen, covers the whole area, and the ponds and streams arising from it at each recession assorted and deposited long lines of sand and gravel, of various breadth and thickness, having a small dip away from the higher portions, as it has been observed these patches actually do have. These in turn would be covered and others formed above them; and in this way the whole mass would be built up. The low dip would give to these lines of sand and gravel a broad outcrop near the higher portions and at the same time would carry it rapidly below the surface; a dip of one degree equals 92 feet per mile, so it is evident that even a much smaller dip than that indicated would carry the sand beds down to the level at which we find them, within a comparatively short distance from the highlands.

We believe then that the water-bearing sands derive their supply from the broad area which they expose among the hills, that the water is kept within them as in a pocket by the all but impervious layer of hard pan; and that when this is penetrated at a point where the surface is lower than the catch basin we have all the requirements for an artesian flow. The distribution of these bands through the drift will explain the occurrence of dry wells, of two or more water-bearing strata in a single well; of the variation in the depth of wells in the same neighborhood, and of the differences in head which the wells show.

THE NON-FELDSPATHIC INTRUSIVE ROCKS OF MARYLAND AND THE COURSE OF THEIR ALTERATION.

By George H. Williams.

1st Paper.

The Original Rocks.

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CONTENTS.

Occurrence and Association. The seventeen hundred square miles which compose the Piedmont plain or area of crystalline

rocks in Maryland is divided by its watershed, known as Parr's Ridge, into two distinct regions. Of these, the more western is occupied mainly with chloritic and sericitic schists containing intercalated beds of limestone. This region is throughout noticeably free from intrusive rocks of any kind, and in this particular it presents a marked contrast to the more highly crystalline gneisses and marbles of the eastern part of the Piedmont area. These are interrupted by large masses of igneous rocks which possess a considerable variety and reprerent three distinct types. These three types, in order of their succession, are as follows:

1. *The plagioclase or gabbro type.* This is the oldest as well as the most extensive of the three. It embraces hypersthene-gabbro and diorite, with from 44 to 48 per cent. of silica, a moderate amount of alkali and considerable alumnia.

2. *The non-feldspathic or magnesian type.* This is closely related to the first type but is of less extent. It embraces serpentines and associated steatitic and hornblendic rocks, together with the pyroxene and olivine masses, free from feldspar, from which these have been derived. They are all very rich in magnesia but almost devoid of both alumnia and alkali.

3. *The orthoclase or granitic type,* quite distinct from the other two. These rocks are richest in silica, alumnia and alkali, and embrace granite, granite-porphyry, felsite (microgranite) and pegmatite.

All of these massive rocks, with the exception of certain of the granites, exhibit the effects of dynamo-metamorphism, which has altered both their structure and mineral composition.

The members of the first type, together with their alteration-products, have already been described by the writer in a memoir[1] which also contains a brief description of the non-feldspathic rocks.

The members of the third or granitic type are reserved for future study and description, although they have already been brought into prominence by Dr. W. H. Hobbs, on account of the allanite surrounded by a regular growth of epidote which they contain as an essential constituent.[2]

[1]The Gabbros and associated Hornblende Rocks occurring in the neighborhood of Baltimore, Md. Bulletin of the U. S. Geol. Survey No. 28, Washington. 1886,

[2]Johns Hopkins University Circulars No. 65, Apr., 1888. Am. Jour. Science (III) vol. 38 p.223, Tschermak's Min. und Petr. Mittheilungen XI, p. 1, 1889.

Relation to the Serpentines. The serpentines of Maryland have long been known on account of the chromite they contain. They stretch in a series of lenticular and irregularly elongated areas along the Maryland and Pennsylvania state line on the northern border of Cecil county, whence they follow the great westward bend in the Appalachians through Harford and a part of Baltimore counties, and then turn to a southwestward direction along the eastern base of Parr's Ridge through a part of Baltimore and across Howard and Montgomery counties to the Potomac.

While by no means regular in their distribution, these serpentine areas lie for the most part on the west and northwest side of the gabbros. This fact is not without significance when taken in connection with the westerly or northwesterly dip of the crystalline schists, as indicating that the non-feldspathic eruptives and their alteration products are *younger* than the gabbros—a result which is quite in accord with all observations made on the field relations of these rocks where they occur together.

The serpentines of Maryland, as well as the extensive hornblendic and steatitic masses with which they are intimately connected, are plainly of secondary origin. They have all been produced by the alteration of what were once basic eruptive rocks, devoid of feldspar, which are still to be found in an almost unchanged condition. From these original rocks the serpentines and their associates can be traced through every intermediate stage so as to leave no doubt as to the exact course of their alteration.

Character of the Original Non-feldspathic Rocks. The original rocks from which the Maryland serpentines and their associates have been derived belong to two distinct, but closely related groups. The members of both of these groups are alike in being too poor in alumina to produce any feldspar, while the mineralogical differences which divide them are mainly due to the smaller or larger percent of silica that they contain.

The rocks of the group poorest in silica (40-44%) are richest in magnesia and are characterized by *olivine* as an essential constituent. They are therefore representatives of the class *Peridotite*; and, according to their greater or less proportions

of lime, they form diallage-bronzite peridotites (Lherzolite), or bronzite peridotites (Harzburgite).

The members of the second group, with from 52 to 55% of silica, are too acid to allow of the formation of olivine, and are therefore composed altogether of pyroxene. To this group we may apply the class name, *Pyroxenite.* These rocks exhibit the same variations in their proportions of lime as the members of the first group; and this gives rise to diallage-bronzite and pure bronzite aggregates which are equivalent to olivine-free lherzolites and harzburgites respectively.

In their distribution, in the occurrence of every intermediate form, and in the similarity of their alterations, these two groups are so closely related that it is impossible to regard them as anything but mineralogical facies of a single magma. Nevertheless, their extremes represent two petrographically distinct and well characterized types, which must be described before attempting to trace out their relationships.

I. *The Pyroxene-olivine Rocks—Peridotites.* This type is much less common than the pyroxenite; not perhaps because it was originally less extensively developed, but rather because it is more subject to alteration, since olivine is a less stable compound under present conditions than pyroxene. Indeed, in even the freshest peridotite specimens obtainable, this constituent, olivine, is partially transformed to serpentine, although not to an extent which disguises the original structure or character of the rock.

The Maryland peridotites have been already described by the writer in a former paper.[3] Their most remarkable feature is their porphyritic structure, which is shown in Fig. 1, Pl. II. The groundmass appears in a hand specimen homogeneous, compact, and of a greenish black color, but under the microscope is seen to be wholly composed of small olivine grains, more or less completely changed to serpentine. Cores of the unaltered mineral frequently occupy the central portions of the grains; and are connected by the anastomosing network of serpentine and magnetite, which has resulted from the partial alteration of the olivine. In this groundmass are imbedded the distinctly porphyritic crystals of pyroxene in which the process of serpentinization is far less advanced than in the olivine. This

[3]Bull. U. S. Geol. Survey, No. 28, pp. 50-55. 1886.

structure indicates that the olivine is the youngest of the original minerals, and it seems therefore opposed to the rule, given by Rosenbusch[4] and others, that, in eruptive rocks, the order of crystallization is in inverse order of acidity, the most basic constituent forming first, etc. The porphyritic structure is always noticeable in the Maryland peridotites, but is much more pronounced in some cases than in others, owing to the larger size of the pyroxene crystals.

In these peridotites the pyroxenic component is always, wholly or in part, *bronzite*. With this is frequently associated *diallage*, which in some instances exceeds the bronzite in amount. The only other original constituent present is magnetite, except in those varietes where the development of a little basic feldspar produces a transition to olivine-gabbro.

In composition these peridotites are ultra-basic ferro-magnesian silicates, with a minimum amount of alumina. Their two varieties—olivine-bronzite aggregates(Saxonite, Harzburg ite) and olivine-bronzite-diallage aggregates (Lherzolite), are produced by the relative proportions of lime present in the crystallizing magma; and hence, as mineralogical facies of the same mass, merge imperceptibly into one another. Analyses of two specimens are here given. I shows the composition of a typical porphyritic lherzolite, from Johnny Cake road, Baltimore county, (No. 174) as determined by Mr. T. M. Chatard of the U. S. Geological Survey. This is the rock represented in Fig. 1. II is the analysis of a feldspathic lherzolite from a dike exposed on the Western Maryland railroad near Pikesville, Baltimore county, (No. 54). It was made by Dr. Leroy McCay of Princeton College.

	I.	II.
SiO_2	43.87	41.00
TiO_2	.12	—
Al_2O_3	1.64	7.58
Cr_2O_3	.44	—
Fe_2O_3	8.96	5.99
FeO	2.60	4.63
MnO	.19	tr.
CaO	6.29	10.08
MgO	27.32	23.59
Na_2O	.50	.52
Ignition	8.72	$\left\{\begin{matrix} H_2O\ 4.73 \\ CO_2\ 3.62 \end{matrix}\right\}$ 8.35
Sp. gr. 3.022.	100.63	101.74 Sp. gr. 2.989.

[4]Neues Jahrb. für Min., etc., 1882, II, p. 8.

In both of these rocks the presence of diallage manifests itself in the amount of lime which the analysis shows. In the second, the presence of the basic feldspar (anorthite) is indicated by the greatly increased percentages of both alumina and lime. The loss by ignition shows a large amount of water, indicating serpentinization of the olivine; and also, in the second instance, the carbon-dioxide proves extensive carbonization of the feldspar and diallage.

II. *The Pure Pyroxene Rocks—Pyroxenites.* The masses of plutonic rocks composed wholly of pyroxene, which are so abundant in Maryland and from which the steatites and possibly some of the serpentines have been derived, are even better worthy of description than the peridotites. This is, 1st, because they represent, in typical and extensive development, an important group of igneous rocks which has not heretofore received its due recognition; and 2d, because the abundance of material in all states of preservation permits of the tracing out of the course of their alteration.

The pure pyroxene rocks of Maryland exhibit two well marked types, of which the darker and heavier is somewhat the more basic and richer in iron. This is composed of bronzite or hypersthene and diallage, while the lighter and more acid type is made up of the same orthorhombic pyroxene and diopside.

The first of these two types, or the hypersthene-diallage rock, is much the more common and has a specific gravity of 3.32. Much of this rock presents an evenly granular texture, both of its constituents being present in allotriomorphous individuals from one to two millimeters in diameter. Only in the thinnest flakes are the colors of these minerals visible to the naked eye. Under the microscope the rock presents a pleasing contrast of red and green; the diallage remaining always of the latter color, while the strongly pleochroic hypersthene changes from one to the other as the stage is rotated. The mineral composition of this rock is monotonous in its simplicity. With the exception of an occasional speck of opaque iron ore no trace of any other constituent is present. The two pyroxenes seem to be about equal in amount, as gauged by a microscopic examination, but the following analysis (III) of a representative specimen from the Johnny Cake road, by Mr. J. E. Whitfield of the U. S. Geological Survey, indicates a slight excess of diallage.

III.

SiO_2	50.80
Al_2O_3	3.40
Cr_2O_3	0.32
Fe_2O_3	1.39
FeO	8.11
MnO	0.17
CaO	12.31
MgO	22.77
Na_2O	tr
K_2O	tr
H_2O (red heat)	0.52
Cl	0.24
	100.03

Sp. gr. 3.318

The microscopic appearance of this rock is represented (though of necessity very imperfectly without the use of color) in Fig.2,Pl.II. The two constituents do not differ materially in the depth of their color, but in the figure the hypersthene is shaded somewhat darker to distinguish it from the diallage. It is rare that either component of this rock exhibits any trace of crystal form, but when such is present it always belongs to the hypersthene, indicating that of the two, this mineral is slightly the older.

The type of rock here described is not uncommon at many localites near Baltimore, but it is to be found in its freshest and finest development along the Johnny Cake road, one mile east of the Patapsco river, and along Gwynn's Falls south of the road leading west from Pikesville Station. At the latter locality the rock often has an extremely coarse grain and it not infrequently contains porphyritic crystals of orthorhombic pyroxene an inch or two in length.

The second and more striking type of the Maryland pyroxenite is considerably poorer in iron, and hence lighter both in weight and color than the rock just described. Even in hand-specimens the two pyroxenic constituents present that contrast of color which in the former type is observable only in a thin section. The orthorhombic mineral is reddish brown while the monoclinic one is emerald green. The grain is in the main even, although a porphyritic development of the bronzite is sometimes observable. The cohesion between the grains is so slight that perfectly fresh specimens may sometimes be rubbed to powder in the fingers. This, together with the size of the individuals, renders the separation of the two

constituents easy, even without the aid of a heavy solution.

The best locality for unaltered specimens of this rock is near Hebbville P. O., on the Windsor road, about six miles west of Baltimore.

The following analyses (IV and V) of two samples of this rock are by Dr. T. M. Chatard of the U. S. Geological Survey, while under VI and VII the composition of each of the two minerals composing rock V is given according to the same analyst.

	IV.	V.	VI.	VII.
SiO_2	53.98	52.55	54.53	51.80
TiO_2	0.15	0.14	—	0.13
Al_2O_3	1.32	2.71	1.93	2.21
Cr_2O_3	0.53	0.44	0.30	0.51
Fe_2O_3	1.41	1.27	1.70	1.29
FeO	3.90	4.90	8.92	3.50
MnO	0.21	0.24	0.28	tr.
CaO	15.47	16.52	2.25	20.99
MgO	22.59	20.39	29.51	17.76
Na_2O	undeterm.	0.27	—	—
K_2O	undeterm.	0.27	—	—
H_2O	0.83	1.09	1.14	0.65
P^2O^5	tr.	tr.	—	tr.
Total,	100.39	100.52	100.56	98.84
Sp. gr.	3.301	3.304	3.300	3.308

The two seperate analyses VI and VII enable us to determine quantitatively the mineralogical composition of this rock, since the microscopical examination shows that it contains no components other than the two pyroxenes. In the specimen from which the material was separated, the ratio of orthorhombic to monoclinic pyroxene is one to three, as is shown by analysis V; but this proportion varies in other specimens, as may be seen from analysis IV, which indicates relatively more of the orthorhombic mineral.

Analysis VI is that of a typical *bronzite*, and the same mineral is indicated by all of the optical properties of the reddish-brown constituent.

The emerald green pyroxene, whose composition is given in analysis VII, is monoclinic, with an extinction angle on the clinopinacoid, ć : c, of 40°. It is to be designated as *diopside*, rather than diallage, since it is translucent and devoid of a pinacoidal parting. This mineral seems to agree in all respects with the chrome-diopside of the lherzolites and other olivine rocks, as may be seen by comparing its analysis with

those of Damour, Oebbecke, Farsky, Cossa and Heddle, quotted by Teall (British Petrography, p. 89.)[5]

The extremely friable nature of this rock renders the preparation of thin sections difficult. Nevertheless its two components may be easily separated and studied independently. The structure is almost always granular; but whenever it is at all porphyritic, the bronzite is the older constituent, so that if correlated with the porphyritic peridotites above described, the diopside supplies the place of the olivine groundmass. This change is produced by an increase of the silica while the proportion of alumina remains too low to allow the formation of feldspar.

Occurrence of Pyroxenite outside of Maryland. Observations are not lacking which indicate that massive pyroxenites of both the types here described from Baltimore county, are extensively developed and widely distributed through the crystalline areas of the eastern United States, although our present knowledge hardly indicates what their real importance is.

Rocks of the first type, or bronzite-diallage aggregates, have been traced by the writer through Harford county, Md., in close connection with the serpentine of that district. Professor F. D. Chester has also recently described them as associated with, and giving rise to many of the state line serpentines of Cecil county, Md., and Chester and Lancaster counties, Pa.[6] It has also been long recognized that many other serpentines of Pennsylvania have originated from the alteration of pure pyroxene rocks, especially enstatite and bronzite aggregates.

Pyroxenites of the second type, bronzite-diopside aggregates, are known in the south, and the writer gladly avails himself of the kind permission of Mr. Geo. P. Merrill of the U. S. National Museum to describe in this connection certain very beautiful rocks of this type which he collected near Webster, N. C. They are abundantly exposed at this locality and form a member of the corundum-bearing dunite series which extends through North Carolina and Georgia. The specimens received from Mr. Merrill are, like the Hebbville, Md., rock, composed entirely of bronzite and a light emerald green monoclinic pyroxene, but they are more acid and richer in mag-

[5]See also the analysis by Player of a chrome diopside from the Lizard gabbros, published by Teall, Miner. Mag. VIII, p. 116, 1888.

[6]Annual Report of the Geological Survey of Pennsylvania for 1887, p. 95. 1889.

nesia than their Maryland equivalents, as may be seen from the following analysis (VIII) by E. A. Schneider of the U. S. Geological Survey.

VIII.

SiO_2	55.14
Al_2O_3	0.66
Cr_2O_3	0.25
Fe_2O_3	3.48
FeO	4.73
MnO	0.03
CaO	8.39
MgO	26.66
Na_2O	0.30
H_2O	0.38
P_2O_5	0.23
Total	100.25

The base of this rock is a saccharoidal and easily pulverent aggregate of brilliant green diopside grains, through which are distributed large and somewhat rounded crystals of a pale brown bronzite, whose diameter is from one to three millimeters. The relative amount of bronzite is quite variable, even in the same hand specimens, as it shows a tendency to concentration in nests or bands, but the porphyritic structure of the rocks is nevertheless very pronounced, and there can be no doubt that the bronzite is decidedly the older of the two constituents.

The specimens obtained by Mr. Merrill from Webster are such admirable representatives of the bronzite-diopside rocks that the name *Websterite* is suggested as a suitable designation for them; and there seems to be no impropriety in extending this term over all the massive intrusives which are composed entirely of monoclinic and orthorhombic pyroxene.[7]

[7]The rocks from Hebbville, Md., and Webster, N. C., find their foreign equivalents in the well known pyroxenite of Russdorf and Mohsdorf in Saxony. These were described by Dathe is 1876 as *Enstatit-olivin-fels* (Neues Jahrbuch für Min., etc., 1876, p. 233,) but he subsequently discovered that the mineral which he considered to be olivine was in reality a pale green pyroxene (diopside) and he therefore designated the rock as *Pyroxen-fels*, (Neues Jahrbuch für Min., etc., 1883, II, p. 89.) Kalkowsky calls the same rock *Enstatit-pyroxenit* (Elem. d. Lithologie, p. 235, 1886.) It was also upon Dathe's earlier description of this occurrence that Wadsworth based his name *Saxonite* for an olivine-bronzite aggregate (Lithological Studies, p. 125, 1884), which was not accepted by Rosenbusch for this reason (Massige Gesteine, 2d Ed., p. 267.) As referring to rocks so much like these here described from Maryland and North Carolina, Wadsworth's name might be revived for this type, but as its use in a new sense could only result in further confusion, it seems better to propose a wholly new designation. (See next page.)

Other plutonic rocks containing neither feldspar nor olivine, which may therefore be properly classed as pyroxenites although they do not belong to either of the two types here described from Maryland, have been mentioned by Hunt[8] from Rougement and Montarville, Canada, and by Dana[9] and the writer[10] from near Peekskill on the Hudson. Similar masses composed of intensely pleochroic rhombic pyroxene (amblystegite), hornblende and biotite were found by Teall[11] in the Hebredean gneiss of northern Scotland, while Hatch[12] reports hypersthene-diallage rocks from Madagascar. Prof. F. W. Hutton[13] in his recent paper on the Eruptive rocks of New Zealand describes as pyroxenites an enstatite-diallage rock forming a dike in the serpentine of the Dun mountain; a hornblende-biotite rock from Dusky sound and a chlorite biotite rock from Martin's bay.

On the use of the name Pyroxenite. The undoubledly wide distribution of igneous rocks free from both feldspar and olivine, suggests the necessity of establishing a class designation, coordinate with the name *Peridotite* given by Rosenbusch to the corresponding olivine-bearing series, and, like this, capable of subdivision into types. For such generic use the term, *Pyroxenite*, is in all respects the most desirable, although it has already been employed as a petrographical name in at least four distinct senses. It is my hope to be able to show that its use as a designation for any rocks except those of igneous origin which are devoid of any feldspathic or olivine constituents should be abandoned.

The name pyroxenite was first used by Dr. T. Sterry Hunt,[14] who applied it both to intrusive rocks composed mostly of pyroxene, like those of Rougemont and Montarville, and to the more or less massive beds or nests of pyroxene so often

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[7]Serpentine which appear to have originated from pure pyroxene rocks have also been described by Drasche from Carinthia, Tyrol and from Ireland (Tschm. Min. Mitth., I, 10, 1871); by Berwerth from Italy (ib. IV, 238, 1876); by Becke from Greece (Tschm. Min.Petr.Mitth., I,461, 1878); by Eichstädt from Sweden (Geol. Fören. Förh., VII, p. 333, 1884); and by Rosenbusch from Baden (Massige Gest., 2d Ed., p. 276, 1885).

[8]Geology of Canada, p. 667, 1873.

[9]Am. Jour. Science, (III), vol. 20 p. 199.

[10]Am. Jour. Science, (III), vol. 33, p. 194, March, 1887.

[11]British Petrography, pp. 71 and 84, 1888.

[12]Quart. Jour. Geol. Soc., vol. 44, p. 345, May, 1889.

[13]Roy. Soc., New South Wales, p. 153, Aug. 7, 1889.

[14]Geology of Canada, 1863, p. 667.

intercalated in the Archean limestones of New York and Canada.[15] Between these two groups, genetically so distinct, no sharp line has ever been drawn. In their text-books, Kalkowsky[16] and J. D. Dana[17] designate as pyroxenite any rock composed wholly or largely of pyroxene, without regard to its origin.

Among the Canadian geologists the term has gradually come to stand almost altogether for the pyroxenic nests or beds in crystalline limestone which contain a great variety of other minerals,[18] and have genetically no connection with the Maryland pyroxene rocks.

Among French authors the use of the term pyroxenite, is again quite different and includes members of the crystalline schists which are not wholly or even principally composed of pyroxene. Thus de Lapparent says: "Les Pyroxénites sont des roches de plagioclase et de pyroxène, qui forment des couches de quelques centimètres jusqu 'à plusieurs mètres régulièrement interstratifiées dans les gneiss."[19] In his recent valuable paper on the "Pyroxenites of the Islands of Morbihan,"[20] Prof. Ch. Barrois describes beds of gneissic rock containing besides malacolite and diallage, quartz, feldspar, garnet, idocrase, zircon, sphene, rutile, apatite, etc. These alternate with layers of fibrolitic mica-schists and are regarded by the author as extremely metamorphosed calcareous beds of a sedimentary series. They are quite identical with the pyroxene-gneiss of Roguédas in Brittany, mentioned by Cross.[21] Messrs. Lacroix and Baret describes as *pyroxénite à wernèrite* a gneissic rock composed of scapolite, pyroxene, sphene and

[15]Catalogue of the Canadian Rocks at the London Exhibition, 1862; and Geological Survey of Canada, Report for 1863-66, pp. 185 and 226.

[16]Elemente der Lithologie, pp. 231-235, 1886.

[17]Manual of Mineralogy and Petrography, p. 488, 1887.

[18]McFarlane: Geol. Surv. Can., Report 1863-66, p. 95.

Harrington: ib. 1877-8, Appendix G., p. 2.

Adams and Lawson: Canadian Record of Science, 1888, p. 188.

To this class also belong the well-known *Malacolithfels* of Rochlitz in Bohemia; the *Erlanfels* of Saxony; and the remarkable diopside nodules which alter to serpentine in the limestone of Montville, N. J. (vid. G. P. Merrill: Proc. U. S. Nat. Mus., 1888, p. 105.)

[19]Traité de Géologie, 1st Ed., p. 620, 1888.

[20]Les Pyroxénites des îles du Morbihan. Ann. Soc. Géol. du Nord, vol. xv., pp. 69-96, 1887-8.

[21]Tschermak's Min. Petr. Mitth., vol. III, p. 372, 1881.

some secondary oligoclase, occurring as a member of the crystalline series near Saint Nazaire, France.[22]

Rocks of this kind would be called by German and English petrographers, *augite gneiss*, and it is a pleasure to see that in his most recent work on rocks of this kind, Lacroix has conformed to this usage.[23]

Finally the name pyroxenite has been temporally employed in still a fourth sense to indicate certain recent volcanic rocks. Zujovics(or Jouyovitch)[24] and Doelter[25] both proposed to use it in this way; but they subsequently substituted *augitite* for it upon discovering the many senses in which *pyroxenite* had already been employed.[26]

If the Canadian use of the name pyroxenite for aggregated nests in crystalline limestone be abandoned, as the French employment of the same term for augite gneiss, and the German use for certain basic volcanic rocks practically have been, we shall then have two parallel series of non-feldspathic plutonic rocks, the one free from and the other containing olivine, which may be further subdivided as follows:—

GROUP OF THE NON-FELDSPATHIC MASSIVE ROCKS.

I. PLUTONIC.

Olivine-bearing. PERIDOTITE (Rosenbusch, 1877)		*Olivine-free.* PYROXENITE (Hunt, 1862.)
1. Picrite, (Tschermak, 1866)	augite.	
2. Wehrlite, (v. Kobell, 1838)	diallage.	Diallagite.
3. Saxonite, Wadsworth, 1884) / Harzburgite, (Rosenbusch, '85)	enstatite.	Bronzitite. / Hypersthenite.
4. Buchnerite, (Wadsworth, 1884)	enstatite & augite.	
5. Lherzolite, (de la Metherie.)	enstatite & diallage	Websterite, (Williams, 1890)
6. Hornblende-Picrite, (Bonney, 1881) (Cortlandtite)	hornblende & augite.	Hornblendite, (Dana, 1880)
7. Scyelite, (Judd, 1885)	hornblende & mica.	Teall's north of Scotland rocks(?)
8. Dunite, (v. Hochstetter, 1859)	chromite.	Hutton's New Zealand rock.

II. VOLCANIC.

Limburgite, (Rosenbusch, 1872)	Augitite, (Doelter, 1882)
Magma-basalt, (Boricky, 1873)	

Gradation of the Maryland Pyroxenites into other Rock types. The bronzite-diallage rocks, which form the types of pyroxenite prevalent in Maryland, can be traced by insensible grada-

[22]Bull. de la Soc. Fr. de Minéralogie, vol. x, p. 288, 1887.

[23]Ib. vol. XII, p. 83, 1889.

[24]Note sur les roches éruptives et métamorphiques des Andes. Belgrade, 1880.

[25]Ueber Pyroxenite, ein neues basaltisches Gestein. Verh. k. k. geol. Reichsanst, 1882, p. 140, and Die Vulkane der Cap Verden, p. 137, 1882.

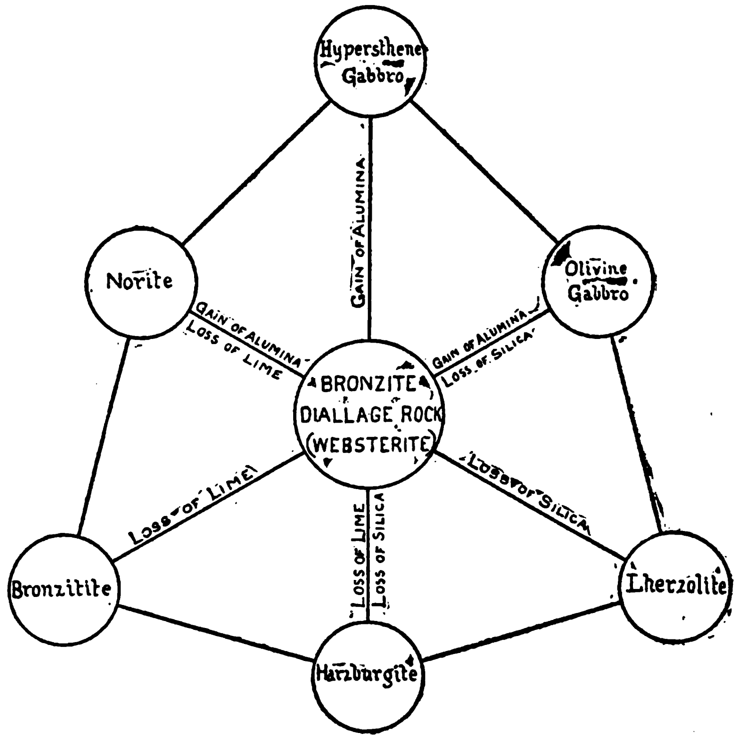
[26]Les roches des Cordillères, Paris, 1884, p. 38-39.

cf. also Rosenbsnch: Mass. Gest. 2d Ed. p. 813, 1885.

tions into other rock types. Their close relationship to the peridotites has already been alluded to, and they appear to be intermediate, both in occurrence and composition, between these rocks and the more abundant hypersthene-gabbros.

If we take the composition of the pyroxenites as shown in analysis III and IV as a starting point, three distinct lines of variation may be plainly traced by an abundance of intermediate types. These are produced by changes in the amounts of one of the three constituents, silica, lime and alumina, as follows:—loss of *silica* produces olivine and makes a *lherzolite;* loss of *lime* obliterates the diallage and makes a *bronzitite;* gain of *alumina* produces feldspar and makes a *hypersthene-gabbro.*

Simultaneous disturbance of the relative proportions of two of these constituents produces intermediate types, whose relations may be seen from the following diagram:



Any of these types might with equal right be taken as a starting point. Together they form a connected series, which

represents the variously differentiated facies of a single magma. Such a magma probably continued to furnish, through a long period, eruptive material, while it was itself undergoing local changes in chemical constitution; or else successive eruptions occurred from a magma which was itself never chemically homogeneous. Such a union of several petrographical types into a geological unit mass is the rule rather than the exception in eruptive areas. It is illustrated in even greater variety in the "Cortlandt Series," near Pekskill, N. Y.,[27] where, as in the neighborhood of Baltimore, certain well-marked types prevail, which are connected by every conceivable intermediate form.

In a later paper the writer hopes to trace out chemically and microscopically the course of alteration whereby the Maryland pyroxenites are transformed into serpentinous, hornblendic and steatitic masses.

Petrographical Laboratory of the Johns Hopkins University, Baltimore, April, 1890.

ICE CLIFFS ON KOWAK RIVER, ALASKA, OBSERVED BY LIEUT. CANTWELL.

By Israel C. Russell.

U. S. Geological Survey, Washington, D. C.

In a recent report of a cruise of the U. S. Revenue Marine steamer "Corwin,"[1] there is an interesting narrative by Lieut. John C. Cantwell, of a boat journey up the Kowak river, Alaska. In this narrative there is a brief account of remarkable ice cliffs forming the river's bank, of the same general character as the ice cliffs at Elephant point, on Eschscholtz bay, several accounts of which have been published.[2] Four

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[27] Am. Jour. Science, (III) vol. 35, p. 447, June, 1888.

[1] Report of the cruise of the Revenue Marine-steamer "Corwin" in the Arctic Ocean in the year 1885. By Capt. M. A. Healy, U. S. R. M. Commander. Washington, 1887, 49th Congress, 1st Session, House of Representatives, Ex. Doc. No. 153, 4to, pp. 1-102, 2 maps and 42 plates.

[2] Descriptions of this locality may be found in the following books:

Otto von Kotzebue: A voyage of discovery into the South sea and Behring's straits, for the purpose of exploring a northeast passage. Undertaken in the years 1815-1818. London, 1821, 8vo, vol. I, pp. 219-220. (See next page.)

illustrations of the ice cliffs are presented, which represent them as bold, angular bluffs, rising directly from the river to a uniform hight, and covered with a layer of soil in which forest trees grow. The cliffs are in reality the eroded border of a forest-covered plateau, under which ice takes the place of rock. The character of the surface of this plateau is described by Lieut. Cantwell as follows:[3]

"Climbing to the top of one of these ice-cliffs, Mr. Townsend and I pushed our way through the dense thickets of willow and luxuriant growth of grass into the interior for about one mile, where we found a shallow lake about a mile in diameter, and which I have no doubt had its origin in the mass of ice over which we had been traveling. It is almost inconceivable how such a rank vegetation can be sustained under such conditions. If we stood in one place any length of time, the spongy moss became saturated, and soon a pool of dark-colored water made our position untenable. Besides the moss, berries, and stunted willows, clusters of spruce trees, some measuring 6 and 8 inches in diameter, have taken root and grown in the thin strata of soil overlying the ice."

Being anxious to obtain a more detailed description of this interesting deposit, I addressed a letter to Lieut. Cantwell, indicating the facts would be of geological interest, and was favored with the reply given below. This information was requested for publication in a paper on the surface geology of Alaska, but owing to delay in the mails, it did not arrive in time to be used in that connection, and is here published in order that the interesting observations it contains may not be lost.

Captain Beechey: A narrative of the voyage and travels of Captain Beechey, R. N., F. R. S., &c., to the Pacific and Behring's straits; performed in the years 1825, '26, '27 and '28. London, 8vo, pp. 372-377.

W. H. Dall: Extract from a report to C. P. Patterson, [On Coast Survey work in Alaska.] Am. Jour. Sci., 3rd ser., vol. 21, 1881, pp. 106-109.

C. L. Hooper: Report of the cruise of the U. S. Revenue-steamer Corwin in the Arctic ocean [in 1880.] Treasury Department, Washing-ing, 1881, 8vo, pp. 24-25.

C. L. Hooper: Report of the cruise of the U. S. Revenue-steamer Thomas Corwin, in the Arctic ocean, 1881. Treasury Department, Washington, 1884, 4to, pp. 79-81, Pl. op. p. 80.

W. H. Dall: Glaciation in Alaska. Bull. Philosophical Society of Washington, vol. 6, 1884, pp. 33-36.

[3]Loc. Cit. pp. 48-49.

U. S. REVENUE MARINE STEAMER CORWIN.

Astoria, Oregon, March 28th, 1890.

SIR:—During the summer of 1884, I was detailed by captain M. A. Healy, Com'g the U. S. steamer "Corwin," to take charge of a small party sent out from that vessel for the purpose of exploring the Kowak river, a stream which had hitherto been unknown, except through native reports and from superficial examinations of its mouth by occasional visiting ships. The river takes its rise in a system of lakes situated in the northwest part of Alaska, flows in a westerly direction and empties into Hotham inlet which is an arm of the Kotzebue sound. Its course throughout is within the Arctic circle and is very tortuous in the vicinity of its delta. The river is navigable for a distance of about 375 miles. Beyond this point the channel is obstructed by rapids and contracted by many small islands and gravel beds. At two points before reaching the head-waters of the stream, we encountered gorges where the width of the stream scarcely exceeds twenty yards and where the channel was filled with rough bowlders. The current at these points was so strong that we were compelled to portage our small boats.

Some seventy or eighty miles from the mouth of the river is where we first observed the ice-cliffs mentioned in my official report. At this point the cliffs were from 125 to 150 feet high, gradually decreasing in hight as we noted their recurrence on our way up stream, until they had entirely disappeared when we had reached the foot-hills of the first chain of mountains through which the river flows. The topography of the Kowak valley in the vicinity of the ice-cliffs is characterized by undulating tundra plains, varied by patches of small spruce timber which, as a general rule, was most abundant along the banks of the stream. The most remarkable example of this curious formation is the first series of ice-cliffs seen on the journey up stream. Here, as before stated, the cliffs are not less than 125 feet high and abut directly on the river. For about a mile, there is exposed to view a solid mass of ice, superposed by a layer of soft earth forming a uniform thickness of about six feet. The surface of the soil is covered by a dense growth of moss and sphagnum. The timber growing over the ice is as heavy as that found anywhere else in the vicinity, being from four to eight inches in diameter and from twenty to forty feet high. The exposed face of the cliff is broken into a thousand fantastic shapes by the combined action of sun and rain, and the lower portion is hollowed out and curved by the constant erosion of the stream.

In color, the cliffs are dark brown, varied by grayish spots where pieces of ice have recently been detached. The ice is not clear, and must have been formed from water holding in

solution a large quantity of earthy matter. There is no apparent stratification. A small piece which I obtained and melted showed a residum composed largely of fine dust, moss and unrecognizable vegetable matter. No gravel was seen either in specimens examined or anywhere along the base of the cliffs. The shore line in front of the cliffs was marked by an accumulation of soft, almost impalpable dust, piled in heaps to a hight of fifteen or twenty feet. The dust piles were evidently the result of the melting of the ice during the summer season, as the annual spring freshets caused by the melting snow on the mountains sweep everything movable before them.

My first impression was that the ice-cliffs were formed by drift ice brought down by the river and forced into the soft soil, but further observations caused me to reject this theory as untenable. In the first place, the ice is solid, without crease or fracture from top to bottom; and, again, there are numerous high sand and clay cliffs abutting on the river in situations exactly similar with reference to the current to those occupied by the ice-cliffs, in which not a particle of ice is to be seen. All of the ice-cliffs are located on the left or south bank of the river and appear and disappear as the course of the stream approaches or recedes from an imaginary straight line joining them. It is a somewhat remarkable fact that if this line should be extended to the coast, it would pass through the ice-cliffs visible on the shores of Eschscholtz bay.

The query arises, may this not be an old glacier which has been buried beneath the deposits of a more recent inundation?

The ice-cliffs can be reached from Kotzebue sound by a party going up the Kowak in a steam launch, in two or three days. It is to be hoped that an effort will be made to send some one competent to make a full investigation of this curious formation, north for that purpose, in some public vessel cruising in the vicinity.

Very respectfully,

J. C. CANTWELL,

2nd Lieutenant, U. S. R. M.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

La Période Glaciaire, étudiée principalement en France et en Suisse. Par A. FALSAN. 364 pages, with a map of the Quaternary glaciers of France, a profile of the ancient glacier of the Rhone, and 105 cuts in the text. Paris: Félix Alcan, 108, Boulevard Saint-Germain. 1889.

The excellent work of M. Falsan several years ago on the drift formation and the ancient glaciers of the central portion of the basin of the Rhone, prepared him well for reviewing in this treatise the history

of the Ice age in France and Switzerland, the action of ice in erosion, transportation, deposition, and the causes of this unique geologic period. Apparently at the same time with the accumulation of the great ice-sheet of northwestern Europe, deep and broad ice-streams poured downward from the Alps to the vicinity of Strasbourg on the north and to Lyons on the west; while the Pyrenees, the mountains of Auvergne, of the Morvan, and the Vosges, nourished glaciers similar to those which remain in the Alps at the present day. The traces of the ancient glaciation of these districts, their moraines and other glacial and alluvial deposits, the loess, and especially notable erratic blocks or boulders, are interestingly described, with numerous illustrations from photographs. For the greater part of France the glacial period was characterized by abundant rainfall with no permanent accumulations of snow and ice; the fauna included the mammoth and reindeer and with them primitive man is known to have been a witness of the climatic vicissitudes of the growth, culmination, and departure of the vast Quaternary glaciers, but the author believes that no proofs of greater antiquity of our race have yet been discovered.

Much attention is given to the progress and changes in opinions in explanation of the facts observed, from the times of DeSaussure, Elie de Beaumont, Playfair, Charpentier, and Agassiz, to the present general assent accorded to the theory of land-ice as the drift-forming agency, first understood in the Alps and thence extended to explain the drift of continental areas. The deep lakes bordering the Alps are attributed to orographic movements, but glacial erosion has produced small mountain tarns. Fjords, however, seem to have been channelled by streams before the Ice age, instead of being orogenic fractures, as they are regarded by this author. After noticing Boucheporn's suggestion of displacement of the earth's axis as the cause of glaciation in what are now temperate latitudes, and Dr. Croll's theory of its dependence on eccentricity of the earth's orbit, both of which are thought to lack sufficient support, M. Falsan concludes that an elevation of the mountains above their present hight was the chief element inducing the formation of the great Quatenary glaciers; and from his study in the Rhone basin he finds evidence of only one glacial epoch, but this included various phases of retreat and re-advance of the ice, by which stratified and sometimes fossiliferous beds came to be intercalated between unstratified formations of glacial origin.

Nearly the same opinions on the cause and the unity of this period are held by Prof. G. F. Wright in his work on "The Ice Age in North America," which was published almost simultaneously with this volume. But if there were in some regions two distinct glacial epochs, separated by a long interval of warm or temperate climate, as many geologists believe to be proved for other alpine districts, for Great Britan, Bavaria, and North America, the repetition of ice-accumulations is ascribed by M. Falsan to repeated uplifts of the land, which, as suggested also by Upham, were not probably synchronous for all

glaciated countries. What the elaborate treatises of Geikie, Falsan, and Wright have done for the Ice age in Scotland, France, and the United States, it now becomes very desirable that others should supply in similar form, attractive to ordinary readers, for its extensive and very important records in Germany, Scandinavia, and Canada. Tourists visiting the French side of the Alps or Pyreenes should not fail to read M. Falsan's book, a duodecimo of the "Bibliothèque Scientifique Internationale;" and it will be found a most valuable hand-book for glacialists everywhere.

Quaternary History of Mono Valley, California. By ISRAEL C. RUSSELL. Pages 261-394; plates XVI—XLIV; and 12 figures in the text. (Accompanying the eighth annual report of the director of the U. S. Geological Survey.)

The reader is very agreeably introduced to the district described in this memoir and becomes acquainted with its principal topographic features and present climatic and physical conditions as a section of the arid and most desert regions of the Great Basin, bounded on the west by the High Sierra, and learns the outlines of its geologic structure and history, while crossing the Mono basin in an imaginary ride with the author on his explorations and ascending with him to the summit of Mt. Dana on the Sierra water-shed, eight miles distant from lake Mono, above which it rises 6,610 feet, to a hight 12,990 feet above the sea. Aside from the scientific value of this work, Mr. Russell has succeeded in telling his observations and conclusions with charming literary skill We almost share with him the exhilaration of field-work, study, and discovery; and numerous maps, sections, and illustrations of scenery, but especially the textual description, bring the region clearly and vividly into comprehensive view.

Lake Mono has a rudely circular outline, with a maximum diameter of 14 miles, an average depth of about 60 feet, and a maximum depth of 152 feet. It has no outlets and its waters are strongly alkaline. Above the present lake, distinct evidences of its expansion and higher levels during the Quaternary era are shown by terraces, shore cliffs, beach ridges of gravel and sand, and delta deposits. The highest beach, varying slightly from its original horizontality, is 670 to 710 feet above the level of the lake in 1883; but at that hight the lake still lacked about 100 feet of reaching to the lowest points of the water-shed, where it would have overflowed either eastward or northward. Only about twenty-five miles distant to the north, the southern extremity of the many-armed lake Lahontan stood, at its highest level, about 2,700 feet below the Quaternary lake Mono, and thence stretched 250 miles northward, itself also without outlet.

The history of lake Lahontan, previously studied by Mr. Russell, finds many close analogies in that of lake Mono, especially in the abundant chemical deposits of lithoid tufa, dendritic tufa, and thinolite, all being calcium carbonate, which frequently form crags, columns, and tower-like masses both above and beneath the present surface of

the lake. It is shown that the formation of the crags and columnar trunks the latter sometimes resembling a forest of gnarled trunks and stumps changed to stone, commenced with the deposition of porous and tubular lithoid tufa from the waters of sub-lacustral springs, and that the cones and tubular masses thus formed were subsequently enveloped in sheathings of the dendritic, thinolitic, and lithoid varieties, precipitated from the lake waters. Careful investigation, however, has not yet determined "why at one time the tufa should have a beautifully dendritic structure, at another time form regular and symmetric crystals, and still again be a structureless stony mass, each deposit having the same composition and being evidently formed from the same solution."

Glaciers of great extent covered the Sierra Nevada excepting its highest sharp peaks and ridges, and flowed down the lateral canons heaping great morainal embankments along their sides and on the broad lower slopes, terminating below the highest Mono beach. Their maximum extension preceded the highest level of the lake, which probably marked a time of rapid melting of the snow and ice on the mountains. There were at least two epochs of glacial extension, besides many minor fluctuations; and what may be termed an interglacial epoch is recorded in the sediments of the ancient lake by an accumulation of gravel separating two heavy deposits of lacustral sediments.

Volcanic action has been displayed on a grand scale in the Mono basin since the high water stage of the lake which followed the maximum extension of the Sierra Nevada glaciers. Some of these points of recent eruption are situated on the islands of the lake, others lie beneath its surface, and still others are found on the southern portion of the basin, where they form part of a range of volcanic cones known as the Mono Craters, which in greater part, however, seems to be of earlier Quaternary age. Beginning less than a mile from the shore of the lake, the Mono Craters extend in a crescentic belt to the southeast and south about eight miles, rising 630 to 2,750 feet above the lake level. All the cones of the range are largely built of lapilli, which have a light gray tint and form smooth, even slopes about the vents from which they were ejected. Interbedded with these accumulations of volcanic rock fragments are thick sheets of black obsidian that flowed in various directions from vents, usually near the crest of the range.

"Owing to the viscid character of the lava at the time of its extrusion, it formed thick sheets which terminated on their lower margins in precipices two or three hundred feet high. The contrast here presented by esentially the same rock under different conditions of extrusion can scarcely be surpassed. The lapilli are loose, vesicular, incoherent, and light-colored, and form smooth, curved slopes of great regularity and beauty; the obsidian is compact, dense, black in color, massive in appearance, and the surface is broken into huge angular blocks thrown together in the utmost confusion.

Reviewing the climatic changes indicated by lakes Mono, Lahontan,

and Bonneville, the author concludes that the early Quaternary was a long-continued period of aridity, and that this was followed by a time of relatively great but not excessive humidity, during which a large number of the enclosed basins of the region became flooded, though many of them were not raised so high as to overflow. Then followed an interlacustral epoch of low water, doubtless coinciding with the principal interglacial epoch, when many, if not all, of these basins were completely desiccated. A second maximum of lake extension followed this arid epoch and was succeeded by another era of desiccation of great intensity, during which and probably not more than three hundred years ago the lakes of the Lahontan basin were evaporated to dryness. Recently a gradual change to a more humid climate brought abont the conditions now characteristic of the arid regions of the West; and Mr. Russell thinks that this latest change has not yet culminated, and that increased humidity in the Great Basin may be expected in the future.

On certain Devonian plants from Scotland. By SIR J. WM. DAWSON. (Nature, April 10, 1890.)

This communication enumerates several species of fossil plants from Perthshire and Caithness, Scotland. The most abundant species is *Psilophyton princeps* Dn. and then *P. robustius* Dn. and *Arthrostigma gracile* Dn. These species constitute a flora which is identical with that of the lower division of the Gaspé sandstones of Canada. The Caithness slabs contain *Cordaites angustifolia* Dn., Which is also found in the Devonian of Canada. The Perthshire plants were noticed in Geikie's "Text-book of Geology," 1882, p. 708, where a good figure of *Psilophyton robustius* Dn. is given, which shows the fruiting. The paper is interesting since it is one of the few cases in which pre-Carboniferous plants can be used for correlating approximately the stratigraphy of two widely separated sections.

The Mammalia of the Uinta Formation. By WILLIAM B. SCOTT and HENRY F. OSBORN. (Trans. Amer. Phil. Soc., Phila., vol. xvi, part iii, 1890, pp. 461-572.)

Prof. Scott contributes part i, "The Geological and Faunal Relations of the Uinta Formation,"in which he discusses the stratigraphical and palæontological relations of the various groups of this formation. In part ii, "The Creodonta, Rodentia and Artiodactyla," he gives some clear and valuable descriptions of the various genera and species from the Uinta; the rodent *Plesiarctomys sciuroides* S & O, a species much inferior to *P. delicatissimus*, is described from well preserved skull, lower jaw and limb bones. In the artiodactyla, Prof. Scott and Osborn's genus *Leptotragulus* (*L. proavus*) is treated at length and its systematic position defined. This genus is regarded as the forerunner of *Pœbrotherium*. Prof. Scott thinks *Homacodon* is the direct ancester of *Leptotragulus*. The former has been placed by Marsh (*Am. J. Sci.* 14, 337) with *Helohyus* in the family *Helohydiæ* against which Prof.

Scott protests with apparently very good reasons. A lengthy discussion of 17 pages is given to *Protoreodon* S & O. In part iii, Prof. Osborn describes the utter confusion brought about by the useless attempts to describe and work from brief descriptions without the aid of plates or cuts. Upon investigation he has found the perissodactyla of this formation considerably mixed up, and it seems proper at this point to call attention to the necessity of ignoring to a certain extent brief descriptions unless accompanied by plates or some other method of illustration. The family *Amyodontidæ* is discussed and a new species *A. intermedium* described and illustrated; *Diplacodon*, *Isectolophus*, *Triplopus* and *Epihippus* complete the part. The memoir is then concluded with an interesting paper by Prof. Osborn on "The Evolution of the Ungulate Foot," and some extremely interesting material is brought forward. Like all the papers from the Princeton Museum this exhibits the usual great care with which their subjects are treated. It is illustrated by well executed plates.

RECENT PUBLICATIONS.

1. *State and Government Reports.*

California state Mining Bureau. Wm. Irelan, Jr., state mineralogist. Ninth annual report, for the year 1889. 352 pp., octavo. Numerous half-tone plates, and other illustrations. Sacramento.

Geological Survey of Texas. E. T. Dumble, state geologist. A preliminary annotated check-list of the Cretaceous invertebrate fossils of Texas. Bulletin No. 4. Robert T. Hill. 57 pp., 8vo.

Geological Survey of Missouri. Arthur Winslow, state geologist. Bulletin No. 1 contains: Administrative report, Arthur Winslow; The coal beds of Lafayette county, Arthur Winslow; The building stones and clays of Iron, St. Francois and Madison counties, G. E. Ladd; The mineral waters of Saline county, A. E. Woodward; A preliminary catalogue of the fossils occurring in Missouri, E. Hambach.

Revision of the genus Araucarioxylon of Kraus, with compiled descriptions and partial synonymy of the species. F. H. Knowlton. U. S. Nat. Mus., vol XII, pp. 601-617.

Notes on the serpentinous rocks of Essex county, N. Y.; from Aqueduct shaft 26, New York city, and from near Easton, Pa. Geo. P. Merrill. U. S. Nat. Mus., vol. XII, pp. 595-600.

Report of the U. S. Geographical Surveys west of the 100th meridian, in charge of Capt. Geo. M. Wheeler, vol. I, Geographical report, Washington, 1889. Quarto, pp. 780, 38 plates, 3 maps.

2. *Proceedings of Scientific Societies.*

The Journal Cin. Soc. Nat. Hist., April, 1890, contains: Description of some new genera and species of echinodermata from the Coal Meas-

ures and Sub-carboniferous rocks of Indiana, Missouri and Iowa, S. A. Miller and Wm. F. E. Gurley; Description of a new species of gigantic beaver-like rodent (Castoroides georgiensis), Joseph Moore; A cave in the Clinton formation in Ohio, Jos. F. James.

The Geological Society of America has issued the following portions of vol. I of its Bulletin: The value of the term "Hudson River group" in geological nomenclature, C. D. Walcott; Some results of Archean studies, Alexander Winchell; Post-Tertiary deposits of Manitoba, J. B. Tyrrell; Sandstone dikes, J. S. Diller; Tertiary and Cretaceous deposits of eastern Massachusetts, N. S. Shaler; The stratigraphy of the "Quebec group," R. W. Ells; Some additional evidences bearing on the interval between the glacial epochs, T. C. Chamberlin; The Cuboides zone and its fauna, a discussion of methods of correlation, H. S. Williams; The Calciferous formation in the Champlain valley, Brainerd and Seely, with a supplement on the Fort Cassin rocks and their faunas, by R. P. Whitfield; Proceedings of the annual meeting held at New York, Dec. 26, 27 and 28, 1889, containing liberal abstracts of papers by Newberry (The Laramie group); Geo. H. Williams (Eruptive serpentines at Syracuse, N. Y.); Clark (Tertiary deposits of the Cape Fear river region); McConnell (Glacial features of the Yukon and Mackenzie basins); Wright (Moraine of recession in Ontario); McGee (Appomattox formation); Geo. H. Williams (Petrographic observations in Norway); David White (Cretaceous plants from Martha's Vineyard); Hitchcock (Oval granitoid areas in the Lower Laurentian); Emerson (Porphyritic and gneissoid granites in Massachusetts); Nason (Watchung traps of New Jersey); Upham (Fiords and lake basins as evidence of elevation and depression); McKellar (Pot-holes north of lake Superior); and the constitution, by-laws and names of the fellows of the society, the whole volume comprising 593 pages.

Addendum to the minerals and mineral localities of North Carolina. Wm. Earl Hidden (Jour. Elisha Mitchell Sci. Soc., Chapel Hill, N. C., vol. VI, part II).

Appalachia, vol. VI, No. 1 contains: The cliff-dwellings of the Mancos canons, Frederick H. Chapin; Some Adirondack paths, Frank W. Freeborn; The Madison boulder, W. O. Crosby.

3. *Papers in Scientific Journals.*

Am. Jour. Sci., May No. Elementary proof of the Earth's rigidity, G. F. Becker; Hornblende of St. Lawrence county, N. Y., Geo. H. Williams; Note on some secondary minerals of the amphibole and pyroxene groups, Whitman Cross; Spangolite, a new copper mineral, S. L. Penfield; Archean axes of eastern North America, J. D. Dana; Metamorphic series of southeastern New York, F. J. H. Merrill; Meteoric iron from North Carolina, L. G. Eakins; Distinctive characters of the order Hallopoda, and additional characters of the Ceratopsidæ, with notice of new Cretaceous dinosaurs, O. C. Marsh. *June No.* Hamlinite, a new mineral, Hidden and Penfield; Notice of new Tertiary mammals, O. C. Marsh.

6. *Scientific Laboratories and Museums.*

Third annual geological expedition into southern Maryland and Virginia. Wm. B. Clark. (From Johns Hopkins University Circulars, No. 81).

On the Cheyenne sandstone and the Neocomian Shales of Kansas. F. W. Cragin. (Bul. Wash. Col. Lab. vol. 2, No. 2).

On some occurrences of Ottrelite and ilmenite schist in New England. J. E. Wolff. (Bul. Mus. Comp. Zool. Geol. Ser., vol. 2).

CORRESPONDENCE.

SOME FURTHER CORRECTIONS OF "NORTH AMERICAN GEOLOGY AND PALÆONTOLOGY."

In accordance with a suggestion in your correspondence of April I send some further corrections of the above work, relating to the Rugose Corals. The lists of species in this group give evidence of thorough and careful research and form a valuable addition to the library and laboratory. The generic descriptions, however, are rather too brief to be of much working value to one not already acquainted with their characteristics. What is sadly needed in this branch of palæontology is a thorough working over of the genera similar to that begun by Messrs Thompson and Nicholson and published some fifteen years ago. In addition to their brevity some of the generic descriptions are misleading and a few entirely incorrect.

In the American species of Acervularia the position of the inner wall is generally *indicated* merely by a thickening of the septa about the central pit. A clintonensis, however, is described by Nicholson as having a distinct wall such as is found in a few of the European species of this genus. The septa generally are well developed though seldom reaching the center.

Craspedophyllum is not a synonym for Heliophyllum. It was founded by Dybowski, in 1873, upon a specimen of Diphyphyllum archiaci Billings, from Columbus, Ohio; in a small pamphlet entitled, "Beschreibung einer neuen, aus Nordamerika stammenden, Devonischen Art der Loantharia Rugosa," St. Petersburg. The description was not inserted in his "Monographie" published the same year but the genus was included in the classification and gave its name to the family including also Heliophyllum E. & H. and Acanthophyllum Dyb. Craspedophyllum is characterized (p. 10) by the narrow central, tabulate area separated from the broad, outer area by a heavy wall and the presence of carinæ in the outer peripheral region. The Annals and Magazine of Natural History for Jan. 1878, (5th ser. vol. I, p. 44 etc.) contains an article by Prof. Nicholson "On the minute structure of the corals of the Geneva Heliophyllum and Crepidophyllum." To this is subjoined the following foot-note, "Descriptions of

the characters of Heliophyllum and Crepidophyllum formed part of a paper, by Mr. James Thompson and myself, which was laid before the Royal Society of Edinburgh in the session of 1875-76, and an abstract of which was published in the 'Proceedings,' vol. IX, No. 95, p. 149." The latter genus was founded upon some specimens from the Devonian of Canada, formerly referred by Nicholson to Heliophyllum (subcæspitosum), and is identical with Craspedophyllum, which upon the most favorable consideration preceded it by two years. In the article above referred to Nicholson states (p. 49) "By Dybowski (Mon. der Zoanth. scler. rug. aus der silur. formation, etc., p. 83) the genus Heliophyllum is placed in a special family Craspedophyllidæ along with two new genera Acanthophyllum and Craspedophyllum, the only character assigned to the family being that there is no accessory wall, that the septa are complete, and that the sides of the septa are supplied with lateral outgrowths." The portion of the classification of Dybowski referred to is here given.

6. Family Craspedophyllidæ.

1. No accessory wall. Septa completely developed.
   - *a* Side faces of the septa supplied with lateral outgrowths.
     Genus, Heliophyllum E. & H.
   - *b* Side faces of the septa supplied with thorny outgrowths.
     Genus, Acanthophyllum Dyb.
2. An accessory wall present, only an outer series of septa existing. Side faces of the septa supplied with lateral outgrowths.
   Genus, Craspedophyllum Dyb.

Prof. Nicholson seems to have entirely overlooked the second division of this family and to have been ignorant of the original description of the genus, otherwise he would not have written, "Indeed I am not acquainted with any genus in which any close approximation to the peculiar structure of the central portion of the corallum in Crepidophyllum, can be found. There is no other recorded genus in which the median portion of the central tabulate area is partitioned off by a distinct wall, with which all the primary septa are connected directly and in which they terminate." The genus of Thompson and Nicholson must then be abandoned and Craspedophyllum retained with its two species, C. archiaci (Bill) Dyb. (not americanum) and C. subcæspitosum Nich.

The genus Chonophyllum E. & H. has been especially unfortunate in its history, its structure being very generally misunderstood and species assigned to it which possess no such structual affinities. It was founded in 1850 by Edwards and Haime upon a specimen figured and described by Goldfuss, in 1826, as Cyathophyllum plicatum. In the same list of Cyathophylla, however, the German scientist had just described an entirely different coral under the same name. Perceiving the duplication he afterwards changed the name of the former to

perfoliatum. Conceived thus in error the genus has seemed ill-fated throughout its history. The original description must be considered largely responsible and this has unfortunately been given a new lease of life in Mr. Miller's work. The writer has in preparation a paper on this genus in which he hopes to make clearer its internal structure; it is sufficient to state here that it is not made up of a series of invaginated cells, has no tabulæ, the septa are not generally equally developed, it has or *had* a wall and possesses a complete vesicular structure.

Of the American species magnificum and ponderosum may be stated certainly to belong to this genus. Belli and vadum are doubtful in regard to their generic relations and must be compared with type structures before they can positively be accepted. An examination of numerous specimens of ellipticum has proven conclusively that they do not belong here; their coarse, vesicular tissue and tabulæ give them structural relationship with Cyathophyllum houghtoni Rominger, as pointed out by this author. (Geol. Sur. of Mich. vol. III, pt. II, p. 105). Capax, with its concentric wrinkles and radiciform processes, deep fovea, and false columella, is removed with equal certainty from Chonophyllum, and sedaliense has nothing in its description or figure to suggest this genus. C. *validum* Hall must be an error of the compiler. Its references belong to C. vadum Hall.

Conophyllum Hall has not the relationship to the above genus that its name would seem to imply, or which Prof. Hall later supposed that it possessed. Its type species, C. niagarense Hall, has been correctly determined by Dr. Rominger to be a Cystiphyllum. (Geol. Sur. of Mich. vol. III, pt. II, p. 138) The frequent rudimentary condition of the septa and the invaginated, blistered cells, shown in specimens from N. Y., Mich., Ind., and Iowa all attest the correctness of this judgment, It is especially unfortunate that Mr. Miller has figured this alone with which to represent Chonophyllum.

There are a number of less important corrections that may be noted before closing;—Zaphrentis cornicula is a well pronounced Heliophyllum; Ptychophyllum should be credited simply to Edwards and Haime; Syringopora? multicaulis Hall is shown by its well developed septa to be a Diphyphyllum—(See Geol. Sur. of Mich. vol. III, pt. II, p. 122) and Cyathophyllum helianthoides Goldf. is not synonymous with Heliophyllum halli E. & H. Specimens of the former from the Eifel show carinæ in places but they are specially distinct from the latter.

WILL H. SHERZER.

Geol. Laboratory, University of Michigan, April 15, 1890.

MILLER'S NORTH AMERICAN GEOLOGY AND PALEONTOLOGY.—I would ask space in your journal for a plain statement of that which is in part personal to myself and in part relates to the work which I recently published under the name of the "North American Geology and Palæontology." Messrs. Dulau & Co. of London, England, ordered several copies of the book, and I took the liberty of sending an extra copy to that book-concern to be delivered to the *Annals and Magazine of Natur-*

al History, of London, for review. In the April number of that journal there appeared a false, malicious and libellous article, under cover of a review of the work. The journal was not sent to me, but I accidentally saw the article and at once wrote a letter to the Annals and Magazine of Natural History, in care of Dulau & Co., who had delivered the book, which letter was returned to me with a refusal to publish it. I do not ask here to expose the cowardice of the anonymous libeller, or to make any criticisms upon the disingenuous management of the Annals and Magazine of Natural History, or its superviency to those nearest home, but I ask you to publish the letter I sent to that journal and append hereto, and on another occasion I will make known the motives that actuated the unwarranted attack, as I recognize the author as well by his feet tracks, as I would if his signature had appeared with the middle name at full length as usual.

Cincinnati, O., May 24th, 1890. S. A. MILLER.

CINCINNATTI, OHIO, Apr. 28, 1890.

Editors of Annals and Magazine of Natural History, London, England :—

The April number of your journal, containing a review (?) of my work on North American Geology and Palæontology fell into my hands to day, at the Public Library of this city. I think the reviewer, instead of being critical, has been intemperate and spiteful, and, though neither the name of the author nor his initials are made to appear, nevertheless, I think he is the same individual with whom I ceased to correspond some years ago; but whoever he may be, and whatever his motives may have been, he has certainly shown himself unacquainted with geology and palæontology.

The reviewer accuses me of "the hard pedantry of refusing initial capitals in specific names." The report on Zoological nomenclature to the American Association for the Advancement of Science, in 1877, page 32, contains the following language: "It is probable that in all cases it would be better to commence the generic name with a capital, and a specific name with a small letter." I have followed this recommendation and so has nearly every American naturalist since that time, and I have given the reason for so doing on page 98 of my work.

But beyond all this, it is the rule adopted, in 1842, by the British Association for the Advancement of Science, and is most emphatically adopted by the American Ornithologists Union, in its code of nomenclature of 1886, in these words: "Specific names should *always* be written with a small initial letter, even when derived from persons or places, and generic names should always be written with a capital."

He complains that I use only one letter "i" in the genitive masculine but, in that regard, I follow the rules of nomenclature of the American Association, as will be seen by referring to page 28 of the report. Again he says, "ignoring the masculine gender of the Latonized words *cheilus* or *chilus*, *rhynchus* and *phycus* (in combination) because the Greek forms are neuter, is not good, even in the dog-Latin of modern naturalists." Prof. Lindstrom, in 1884, in his great work on the Si-

lurian Gastropoda made the genus *Onychochilus* and the species *O. cochleatum* and *O. reticulatum*. Prof. Whiteaves, in 1884, made *Codonocheilus* and *C. striatum*. Prof. Hall, in 1885, made *Prorhynchus*, *P. angulatum*, *P. nasutum* and *P. quadratum*. Prof. Whitfield, in 1882, made *Streptorhynchus cardinale*, and in the Annual Rep. Geo. Sur. Wis. for 1877, page 50, he made *Palæophycus plumosum*. If this reviewer is correct, Lindstrom, Whiteaves, Hall, Whitfield and many others whom I might name are "illiterate amateurs," whose knowledge of Latin is not above the barking of a dog. It happens, however, they are distinguished naturalists, and some of them are distinguished linguists, and they have all conformed to the laws of language and the laws of nomenclature in the use of these words, for the rule is, the Greek word takes on *only* the form of the Latin language and retains the gender and meaning which belong to it. I have followed the laws of nomenclature, and the practice of all scientific men of this country, and so far as I am advised the learned naturalists of other countries.

I have before me Andrews' Latin Lexicon, published by Harper Brothers, New York, 1872. On page 46, "*aegilops*" is defined as "*A kind of oak with edible fruit (acorns), Quercus aegilops*," and the palæontologist who used the name for a species did so because his fossil was like an acorn. On page 170, "*aucella*" is defined as "*A litle bird*," and no other definition is given, and it was used by the palæontologist, from a fancied resemblance of his fossil to a small bird. On page 195, "*bellulus*" is defined as "*pretty, elegant, lovely, beautiful*," and the name has been used in American palæontology only in the sense of "*very pretty*." On page 261, "*cerasus*" is defined as "*a cherry*," and the palæontologist used the name "*cerasiformis*" because he thought his fossil was "*like a dried cherry*." On page 811, "*insectus*" is defined as "*non sectus*," and the word when applied to a fossil has been used in the sense of "*uncut*." On page 1523, "*temerarius*" is defined as "*accidental, casual*," and it is only in that sense the word is used in palæontology. On page 1652 of Liddell and Scott's Greek-English Lexicon, published in 1872 by Harper Brothers, New York, one of the definitions of "*cheilos*" is "*the edge*," and the palæontologist who used "*dikrocheilus*" used it in the sense of "*two edged*" or "*having two edges*." "*Mummiform*" is defined in Webster's Unabridged Dictionary, as "*resembling a mummy*," and "*mumiformis*" has been used as a specific name for a black, carbonaceous fossil which the author fancied "*resembled a mummy*."

A glossary is defined by Webster as "*A collection of glosses or explanations of the special meanings and difficult terms of a work*," and so far as I am able to discover the correct special meaning of each of the above words is given in my glossary. But your reviewer may say I have not accounted for all the errors he has found, that make him "*sorry for the amateurs*." Well, he has found some typographical errors that would be patent to the merest beginner, for instance, "*altilis*" means "*fattened*," and the types have made it mean "*flatten-*

ed." and "*vadosus*" means "*full of shallows*," and the printer read the two "*ll's* in the manuscript for a "*d*" and thus printed "*shadows*" instead of "*shallows*." In this country, a pretended critic guilty of laying stress upon a transparent typographical error would be regarded as having a mind too "*shallow*" to entitle him to any consideration. How about "*Turrilepas*" not "*turrilepas?*" On page 257 of my work, the word "*Lepas*" is defined. On page 569, an accidental mistake of my own or of the printer exists. for the word is correctly defined, in the edition of my Catalogue of Palæozoic Fossils, in 1877, and the meaning of the word has been well known to me as well as the fossils bearing the name for twenty years. How about "*Leperditia?*" There I made a mistake and the only one mentioned by the reviewer worthy of consideration. I never saw the memoir of Rouault, and never heard the proper name, Leperdit, until since the publication of my work, when Prof. Lindstrom, recognizing the difficulty of finding the special meaning of some technical names, very kindly gave me the information, by letter.

The reviewer, however, reaches, the climax of his spite or ignorance, in the closing paragraph, when he says, "*Above all, gracilius, a, um, majus, a, um, and minus, a, um, the neuter comparative forms of gracilius, magnus and parvus. Had he given us also, plus, pla, plum, he would have made the series nearly complete.*" On page 952 of Andrews' Latin Lexicon, you will find "*minus, a, um;*" on page 916, you will find "*majus, a, um;*" and on page 687, you will find "*gracilus, a, um.*" They are good latin words. Prof. Hall, in 1888, in Pal. N. Y. vol. 7, p. 34 made "*Gomphoceras minum,*" and I might point out where each of these words has been used by eminent palæontologists of this country, but there is no necessity for so doing, as I made a glossary for the purpose of indicating the special meaning the authors had intended to indicate, and not to criticise or belittle their taste, in the selection of names. Besides the tendency of naturalists is to retain names in spite of faults. "*Plus, pla, plum*" is the Latin of the critic in question, and it will compare favorably with his knowledge of geology and palæontology, and I doubt not with his other scientific attainments.

Very Respectfully,

S. A. MILLER.

USE OF THE TERMS LAURENTIAN AND CHAMPLAIN IN GEOLOGY. In the April number of the AMERICAN GEOLOGIST there is an article on the names Laurentian and Champlain to which some corrections and additions may be of use. At p. 179, *Historie du Canada* par F. X. Garneau, tome I, Quebec, 1845, we read: "La chaine des Laurentides, montagnes qui séparent les eaux qui se versent dans le St. Laurent de celles qui tombent dans la baie d' Hudson". And in a foot note after the word Hudson at p. 180, we read: "Cette chaine n' ayant pas de nom propre et reconnu, nous lui donnons celui de *Laurentides*, qui nous parait bien adapté à la situation de ces montagues qui suivent une direction parallèle au St. Laurent.

The first time the name was used in geology with the signification attached to it by its originator, is at p. 18, *A geological map of the United States and the British Provinces of North America*, by Jules Marcou, Boston, July, 1853, where we read: "System of mountains, which I shall call, after the example of the author of the *History of Canada*, Mr. F.X. Garneau, the *Lawrentine Mountains*," and at p. 67 "*Lawrentine system*—The granitic, syenitic and gneiss rocks, which make the foundation of the Lawrentine Mountains."

Logan, one year and a half after the publication of my volume, in his *Report of Progress for the year 1852-3*, Quebec, 1854, but not issued until April, 1855, speaks at p. 7 of "the metamorphic hills to which Mr. Garneau in his History of Canada has given the name of the Laurentides"; and in the following page he uses the name of *Laurentian series*, directly below the Potsdam sandstone, without a single rock between them, suppressing the 25 or 30,000 feet of strata found and described by Dr. Emmons, under the name of Taconic system.

From these data and quotations, it is very clear that the proposition of my good friend Francois Xavier Garneau was unknown to all geologists, until I pointed it out in July, 1853.

On the 20th of November, 1850, Desor proposed, before the Boston Society of Natural History, to name some Quaternary marine shell deposits the *Laurentian*, and the 19th of May, 1851, he gave more force to his proposition in publishing a paper with a section in the *Bulletin of the Geological Society of France*, vol. VIII, pp. 420-423. He distinguished two terrains and called the marine shell deposits *Laurentian* or *terrain Laurentien*, because it is especially well developed in the basin of the St. Lawrence river. Logan in using Laurentian in 1855 for masses of crystalline rocks duplicated the name, and acted against the right of priority; notwithstanding his explanation that he took the name from the mountain chain of the Laurentides, and not from the valley of the St. Lawrence river.

Champlain as a designation of the Quaternary clay of the same region and as a synonym of Laurentian is even more against all right of priority and against all sound principles of nomenclature. As far back as 1842, Dr. Emmons, the founder of the Lower Palæozoic classification and nomenclature, proposed the name *Champlain* to designate all the strata containing the second fauna, and the name of *Champlain group* or *Champlain system* has been used constantly ever since by almost all geologists, the Geological Survey of Canada included. The idea of proposing for the second fauna group of strata the name *Ordovician* as late as 1879, and to use it in America instead of Champlain is a rare example of passing over all right of priority, and of substituting fancy and caprice for rules used in natural history. But the return and enforcement of right of priority in geological nomenclature and classification is certain one day or another, and the sooner the better, for there is actually a tendency to increase geographical names at such a rate, and confusion has already taken such proportions, that the constant

demand for explanation will force a return to the rules used in zoology and botany. JULES MARCOU.

Cambridge, Mass., April, 1890.

SOME OBSERVATIONS ON NATURAL CASTS OF CRINOIDS AND BLASTOIDS FROM THE BURLINGTON LIMESTONE. The Sub-carboniferous series of rocks of the Mississippi valley is a perfect storehouse of fossil Echinoderms, and fortunate is the naturalist whose "lot has been cast" near such famous collecting ground as Burlington, Keokuk or LeGrande, Iowa; Crawfordsville or Bono, Indiana.; Chester or Warsaw, Ill.; Cowan, Tenn.; Bowling Green, Ky., or Huntsville, Ala.

To understand the richness of this fauna the collector has only to visit such collections as that of Messrs Wachsmuth and Springer at Burlington, Ia., or the state collection at Springfield Ill.

No other locality in the world has yielded such a richness of forms and species as Burlington, Iowa. It was here that many structural peculiarities of Crinoids were discovered or more perfectly understood, as we learn from the Illinois state reports on geology and palæontology and the writings of Wachsmuth and Springer.

In our collecting ground (Pike Co., Mo.) while the Lower Burlington limestone is represented by its usual thickness of thirty to fifty feet, the upper beds are but poorly represented by a few feet of limestone and lose cherts scattered over the hills and along the streams. Many of these cherts or flints are rich in natural casts of crinoids and blastoids and furnish interesting collecting, especially interesting in the structural character of the specimens.

Among some two thousand or more chert crinoids and blastoids in our collection are many beautiful and instructive natural casts of Strotocrinus, Actinocrinus and scores of other genera of crinoids.

Among this material are specimens showing the socalled internal convoluted digestive sack, the radiating tunnels beneath the vault with their accompanying ambulacral tubes, and many other vault features.

As but few of these casts show the arms, columns or probosces attached, we conclude the movements of the water here were more violent then at Burlington, where such appendages are not so rare.

Among the specimens with arms attached, only Eretinocrinus, Platycrinus and Cyathocrinus have been found, two of the first named, two of the second and one of the third.

Of a great many specimens of several species of Dichocrinus not one preserves the vault and this is a little surprising in as much as the related genus Platycrinus is represented in the collection by about twenty-five individuals of perfect bodies. However, we might say that, although Platycrinus is fairly plentiful, not one individual in twenty preserves the dome, while Dorycrinus, Agaricocrinus and Batocrinus, the most abundant forms in the cherts, are rarely without it.

Less than one-fourth the examples of Actinocrinus, Physetocrinus and Strotocrinus preserve the ventral surface, while isolated domes

with the higher plates of the calyx of the two last named of the genera are quite as common as lone calyces.

Imperfect examples of Batocrinus and Eretinocrinus are generally specimens without the basal plates, only. Sometimes an individual has been injured about the base of the anal tube, but rarely. Imperfect Dorycrini either want the basal plates or have suffered breaks in the vault at the spine bases or around the anal aperture. Ollacrinus and Rhodocrinus are rare in any condition. Usually as isolated calyces. Sacocrinus is rare and seldom has the vault in place.

In a very few instances we have noticed remains of small radiating calyx tubes that were imbedded in the substance of the radial plates, and have traced them from the middle of the first radial to the arm bases, bifurcating with the plates. Similar rods on the ventral surface are not rare, but we do not remember having seen any notice of these radial tubes in the calyx, by any writers on crinoids. Fragments of these tubes can be distinctly seen on a specimen of Physetocrinus in our collection. As these tubes, represented by delicate rods in the casts, were free their entire length, the slightest jar would usually destroy them and so not one cast in a thousand shows any traces of such vessels.

Among blastoids, Pentremites elongatus is the rarest with one exception, a Troostocrinus? represented by but one specimen in the collection. Of hundreds of examples of Granatocrinus norwoodi not one shows the central opening above closed by plates, while specimens of Schizoblastus sayi not unusually show this feature.

Specimens of G. norwoodi often preserve the ambulacral rods but the jar in breaking the flints usually destroys them The preservation of these rods on S. sayi is much more rare.

On many of the casts of blastoids the spiracles and hydrospires are well shown. No specimens of blastoids have been found with pinules attached.

We have one specimen of a Platycrinus which had a rather large anal opening entirely closed by minute plates. Perhaps it is an abnormal feature. R. R. Rowley.

Curryville, Mo., March, 1890.

Modiolopsis oblonga. In the May number of the Geologist, vol. v, p. 272, Mr. Ulrich describes a species with the above name. It is unfortunately pre-occupied, Mr. U. P. James having in 1882 proposed this name in place of *M. sub-spatulata* which had been previously used by him, and which Hall had also used. (See "The Palæontologist," Sept. 12, 1882, p. 53). Joseph F. James.

Washington, D. C., April 29, 1890.

PERSONAL AND SCIENTIFIC NEWS.

PROF. J. W. SPENCER, STATE GEOLOGIST OF GEORGIA, who has been in England during the winter months, has returned, and has resumed his work. His address is Atlanta.

THE THIRTY-NINTH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will be held at Indianapolis, Ind., begining August 19, 1890. Committees of the Indiana Academy of Science, and of the citizens of Indianapolis are actively engaged in the preliminaries of this session. The enthusiasm which they manifest bespeaks a full and very satisfactory session. There will be, in connection with this session, the summer meeting of the Geological Society of America, in which the geologists of America are specially interested. Numerous important papers will be presented.

AT A RECENT MEETING OF THE GEOLOGICAL SOCIETY OF LONDON, Feb. 26, 1890, Dr. George J. Hinde exhibited specimens and miscroscopic sections of Radiolarian chert from the Ordovician strata (=Llandeilo-Caradoc) of the southern uplands of Scotland, in the counties of Lanarkshire and Peebleshire. The specimens were submitted to Dr. Hinde by B. W. Peach, Esq., of the Geological Survey of Scotland, for the purpose of ascertaining if the chert of this series resembled that of the Carboniferous in being of organic origin. The microscopic sections show that the rock is filled with small sphericsl bodies that in many instances prove to be simple or concentric lattice-like shells, some with long radical spines, precisely similar in character to the shells of recent and fossil Radiolaria, and it is probable that they may be included in the same genera with recent forms. This is the first definite notice of the presence of undoubted Radiolarians in palæozoic strata. To Prof. H. A. Nicholson, of Aberdeen, belongs the credit of having first noticed the organisms in the chert; but in his specimens only casts without structural characters were preserved, and they were conjectured to be Radiolarian, a conjecture which is now shown to be correct. In this notice we have quoted freely the language employed by Dr, Hinde in describing his remarkably interesting exhibit.

PROF. O. A. DERBY, so long director of the geological subsection of the Brazilian National Museum at Rio de Janeiro, is no longer connected with that institution. He continues, however, in charge of the geographical and geological survey of São Paulo, which will enable him to still carry on his geological work in Brazil.

LIEUT. A. W. VOGDES HAS BEEN TRANSFERRED from Fort Hamilton to Fort Canby, state of Washington. His P. O. Address is Astoria, Oregon.

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CHARLES ALBERT ASHBURNER.[1]

By ARTHUR WINSLOW, Jefferson City.

Charles Albert Ashburner was born on February 9th, 1854; he died on December 24th, 1889. The time of birth, the time of death, these are the abcissæ of man's activities on earth; by the magnitude, by the qualities of his works are the ordinates measured; the area thus limited expresses the value of the life; the bounding curve, often irregular, is a function of many variables, but all are assignable to heriditary traits or to the conditions of life. The abcissæ, the periods of activity, we can readily express in units of time; but who can gauge the ordinates, the qualities of these acts? Infinite wisdom only. We can but surmise, can but express opinions, at best approximate. Of values, the future is the best judge; for, in proportion as a man's character and work affect the future, through the present, so should his value be measured. With us, the contemporaries, it rests, however, to hand down, to this tribunal of the future, accurate pictures of those who pass away; pictures which shall be for ever inseparable from the works of those whom they represent; that future generations may know of what manner of man the work perishes, of what manner of man it endures forever. With this feeling is this sketch prepared, with this sense of the obligations involved; prepared

[1]For much of the matter contained in this sketch, the writer is indebted to Mrs. Ashburner and to Mr. O. B. Harden, of Pittsburg, Pa.

by one who knew Mr. Ashburner first as a superior officer, later as a professional associate and friend.

Beginning with the time of his birth, we will touch upon the epochs. To the bare narrative of facts we will add such suggestions, such interpretations and such illustrations as will, in our calm judgement, help to best picture the man, claiming for them only the recognition due every honest opinion, and resting confident in the belief that, in proportion as it is truthful will this picture live.

Mr. Asburner's great grand-parents on both sides, came directly to Philadelphia from England, about the time of the Revolution. His father was Algernon Eyre Ashburner, the mother Sarah [Blakiston] Ashburner, and he one of the nine children of whom only two are now living. Of what are recognized as English traits there seemed to be, however, no remnant left in Ashburner. On the contrary, his impulses, his mental attitude and his acts were typically American. He was of a nervous temperament, his action quick, his mind inventive and fertile in resources. How much of this was inherited, how much acquired, we cannot say. His education was entirely American. The early part was at Friends' Central School in Philadelphia, then at the High School of the same place and afterwards at the Towne Scientific School of the University of Pennsylvania. Of his career during these early years little is known to the writer. At the early age of sixteen, in September, 1870, he entered the University of Pennsylvania and was graduated in 1874, first in his class, as civil engineer· While at the University, a classmate writes: "I was early impressed with his mathematical ability, his determination to lead, and his energy in carrying that determination to a successful culmination." But, in addition to this success in his studies, he was further fortunate in drawing to himself, during his last college years, the interest and attachment of professor Lesley, who then occupied the chair of geology at the University. How much of the shaping of Ashburner's career are we to attribute to this association? To this influence one naturally concludes, it was due that the career of the civil engineer was abandoned for that of the geologist. Thus, while an undergraduate, in 1872, he took part in a survey of the raft channel of the Delaware river, between Easton and Trenton; he was one of the organizers of the Engineer's Club of Philadel-

phia in 1873; further, upon graduation, he accepted a position on a light-house survey, under Gen. W. F. Reynolds and with professor Lewis M. Haupt. But, in the same year, on the organization of the second geological survey of Pennsylvania, he seems more than ready to leave this work of the civil engineer to begin his life's work as a geologist, even as a volunteer assistant on the survey. Thus early did this friendship of professor Lesley make itself felt, and it was ever after an important factor in Mr. Ashburner's life; a strong and sincere attachment which now expresses itself in beautiful, but pathetic words of grief for the departed pupil and friend.

We can add nothing to what has already been written of the first years of his work on the Pennsylvania survey, of his work in Mifflin and Juniata counties in 1874, in the Aughwick valley and East Broad Top district in 1875, in McKean, Elk, Forest and Cameron counties in 1876.

It was in the late summer of 1881 that we first met Mr. Ashburner, at Wilkes Barre in the Wyoming valley, he, then, but recently married. The work of the survey of the anthracite regions was already planned in detail, branch offices were opened at Pottsville, Hazelton and at Wilkes Barre, and much progress had already been made. It was a time of buoyant moods with Ashburner. He was under the exhilarating effects of the opening of a successful professional career. He gloried in his responsibilities and in the importance of the work entrusted to him—he only twenty-seven years of age. To some he seemed over confident, enough to excite scepticism, while others would find cause to take slight offense. But there was no bad feeling, no real arrogance in his self reliance.

From early in the year 1882, for over two years the writer was associated with Mr. Ashburner in the work in the anthracite regions. Though not the first to use the contour method of illustrating under-ground structure, Ashburner seems to have been the first to use it extensively and his results are certainly unparalleled. And this very case of applying to so general an end a process which hitherto had been of such limited use, was an illustration of what was one of his characteristic traits, i. e. what has been called the "adaptive faculty", or the power of putting to their best uses, of extracting the full value of such means as were at his disposal. He was fertile in expedients. He was, perhaps, rather an organizer, a man of system, than a

brilliant generalizer. His methods were accurate, and he perseveringly attempted to perfect the details; his work was well systematized and he drilled his forces admirably. Somewhat too much systematizing, too much drilling, we young men use to think, wishing youth-like, to be free from all restraint. We resented it at times, but, since, have appreciated more, that it was rather a striving with him to reach his ideal of the adjustment of parts, than an arbitrary exercise of power. He was, himself, a most unremitting and persevering worker. His judgement of men, his power of reading character was good and hence his selection of assistants and his allotment of work were generally admirable; and, as writes a critic, he had, to a marked degree, the ability of making the best possible use of this work. At one time we thought he did not properly appreciate our share in such, but have since had cause to modify this opinion.

To his assistants he was most kind and cordial, encouraging them to develop the best that was in them, and, to his friendly interest in their careers and to his loyalty in after life, many can testify. But he was not what is called a "magnetic man;" there were many who did not like him, though generally recognizing his ability; his self-confidence was not always flattering to the self-esteem of others; yet his versatility and information on a wide range of topics made him a most entertaining companion. That which was sterling in him did not show out on first and short acquaintance; in fact it was years before the lovable and the cordial of his nature became apparent to some; traits to which the warm expressions of many now pay eloquent tribute.

The work in the anthracite regions and other duties connected with the Pennsylvania survey, occupied Mr. Ashburner until late in the year 1886. At this time he had held the position of first assistant geologist for over a year, having general supervision of all the office and field work of the survey.

After his resignation from the Pennsylvania survey, in 1886[2] Mr. Ashburner went to Pittsburg to take the position of engineer and geologist with the Fuel Gas and Manufacturing Company, one of the associated Westinghouse companies.

[2]For most of what follows relating to Mr. Ashburner's career in Pittsburg and elsewhere, the writer is indebted to Mr. C. B. Harden of Pittsburg, for many years Mr. Ashburner's friend and trusted assistant.

He continued in an advisory capacity with this company up to the time of his death, having reported upon and advised on the drilling of a large number of gas and oil properties. During this time he made a large number of reports for private interests, outside of his connection with the above company; for, having made the subject of the occurrence of oil and gas a special study, his services were much sought after.

In September, 1888, he was elected general manager of the New York and Montana Mining and Milling Company, and retained that position until a month before his death.

In the fall of 1888 he was commissioned, by Mr. George Westinghouse, Jr., to investigate and report upon a number of copper properties, and, after many negotiations and personal examinations, he purchased a large property in southern Arizona, and when the Duquesne Mining and Reduction Company was incorporated, in December, 1889, he was made Vice-President and General Manager.

On November 2nd, 1889, he left Pittsburg for the west for the purpose of starting mining operations, after having been delayed for several days on account of a cold which had clung to him after his return from a trip to Ottawa. This visit to the west was for the purpose of buying and transporting, twenty miles from a railroad line, boilers, engines, and everything necessary to inaugurate a new mining enterprise, and, as was his wont, he went at it in his enthusiastic way, and so overtaxed himself. But, little thinking of the approaching end, he writes from Tombstone, under date of November 20th, in glowing terms of his professional success and prospects, and concludes with the following words, which now sound most pathetic: "I hope some day I may be sufficiently well off to return to state geological work where my heart has always been." But soon after, on November 26th, he writes from Tucson that he has been much delayed during the week by a severe attack of sickness which prostrated him and which his physician thought might develop into mountain fever. After staying at Tucson a few days, he went to Wilcox to report on a gold and silver property, some thirty miles or more from the railroad, and he thought that the drive into the mountain would do him good; but, on his return to Wilcox, feeling no better, and finding a message of solicitation from

home, he decided to return and not to go on to San Francisco as he contemplated.

He returned home on December 9th, and on that day spent half an hour at the office. He was advised by his physician to remain at home, which he did, attending to business matters as they came up. On December 16th his condition became such, owing to Bright's disease, that he was compelled to take to his bed. Sick as he must then have been, however, it did not deprive him of his natural geniality and hopefulness for the future. Accepting, as he had, the responsibility of all that appertained to his new enterprise, he wanted his hand on the helm, to know that everything was going as it should in Arizona, and up to the day before he died he directed the affairs of the Duquesne Mining and Reduction Company; then he was induced by Mr. Westinghouse to give up all thoughts of business, and to try to get well. On that day he had written in pencil a letter of four pages to Arizona, and had directed everything preparatory to taking a rest and to getting well; but the rest did not come in time. On the day before Christmas, after he had thought of and provided for his family and friends in the approaching Christmas festival, he passed away from his loved ones and those he esteemed as friends.

In 1881 Mr. Ashburner married Roberta M. John of Pottsville. It is in a man's home life that his true self is exhibited, and those who were permitted to cross the threshold, at once felt the genial influence of his home life. He idolized his wife and his two children, Elizabeth and Lesley, and no labor was too great or expense too much that might give them pleasure. His wife was a graduate of Wilson College, and her interest in and appreciation of scientific work must have aided him much in his work.

Mr. Ashburner had taken three degrees in the University of Pennsylvania: B. S., M. S. and D. S. C. Of these he was most proud of the last. He took his honorary degree on June 5th, 1889, and it is worthy of mention that he was the first graduate of the University to receive this degree from the alma-mater, and that the original nomination came from the faculty, with whom he had pursued his undergraduate studies, and was cordially confirmed by the Board of Trustees who had personal knowledge of his work.

He took charge of the collection of the coal statistics for

the United States Survey in 1885, and issued reports for 1885, 1886, 1887 and 1888. He took great pride in the collection of these statistics and the issuance of the reports, so much so, that the work was largely a labor of love. In August, 1889, he assumed charge of the collection of the coal statistics of Pennsylvania for the Eleventh Census, as special agent, and was engaged on this work at the time of his death.

Mr. Ashburner was a member of Calvary Episcopalian church at East Liberty and a member of its brotherhood. Of him, a former rector writes: "One can never measure the influence of such a life as his, full of active benefit to his fellow men in the world, doing his full duty as a scholar and man, honored for his ability and devotion to his secular work, and yet always bearing witness for his Lord and for his faith by the upright, loyal, christian character of his manhood." Further, writes another, and an intimate friend: "One of Charles Ashburner's pet ideas was the harmony [or rather the identity] of true Religion and true Science."——"Abreast with the most modern thought, accepting every established doctrine of the latest science, he yet saw in none of these anything whereby he was debarred from an honest confession of his Lord and Savior in the Christian creed, nor from a due and faithful reception of the holy sacrament."

Mr. Ashburner was an active member of the following societies: American Philosophical Society; American Institute of Mining Engineers; Philadelphia Academy of Natural Sciences; American Association for the Advancement of Science; American Society of Naturalists; Engineers Club of Philadelphia; Honorary member of the Lackawanna Institute of History and Science; Franklin Institute of Philadelphia; Trinity Historical Society; Texas Historical Society and a Corresponding member of the Wyoming Historical and Geological Society.

A review of his publications and of his works would be beyond the scope of this paper. These publications and this work are now before the world and their worth is being tested every day. They can be consulted and judged of by many, and many are familiar with them. An estimate of their relative and absolute values has already been given by one more

competent to judge than the writer.[3] Thus we will be content in submitting the following list of his professional papers, which, by their number and by the importance of their topics, give some measure of the prodigious industry of the man and of the character of his work. All of this he had produced and yet had not reached his prime. Surely, death seems to have ruthlessly cut short a most useful career. But, though the friend is gone, though the body is dead, the man yet lives in these his works and this influence will never die.

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Description of the Wilcox Spouting Water well; Amer. Phil. Soc Sept. 1877.

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Report on the Metric System; Engineer's Club, Phila. April, 1878.

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Notes on the Geology of Potter Co.; Report G3, Geol. Surv. of Pa.

The Geology and Description of the Bradford Oil District; Amer. Inst. Min. Eng. Feb. 1879.

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The Geology of McKean Co.; Report G, Geol. Sur. Pa. 1886.

Geological Atlas of McKean Co.; Atlas R,* Geol. Sur. of Pa. 1880.

Description of the Flannery Boiler setting for the Prevention of Smoke; Amer. Inst. Min. Eng. Oct. 1881.

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[3] Obituary Notice of Charles Albert Ashburner, by J. P. Lesley. [Read before the American Philosophical Society, February 21,1890.] Biographical Notice of Charles A. Ashburner, by J. P. Lesley. Trans. Amer. Institute Mining Engrs., Washington meeting, Feb. 1890.

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Report on the Geology of Elk, Cameron and Forest Cos.; Geol. Sur. Pa. Report R2, 1885.

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Second Report of Progress Anthracite Survey; Pt. 1, 1884, Geol. Sur. Pa.

Geological Atlas of Southern Anthracite Field, 1882.

Ditto	Northern	Ditto	1885.
Ditto	Western Middle,	Do	1884.
Ditto	Eastern Middle,	Do	1885.

The Product and Exhaustion of the Oil Regions of Pa. & New York; Amer. Inst. Min. Eng. Sept. 1885.

The Geology of Natural Gas in Penna & New York; Amer. Inst. Min. Eng. Sept. 1885.

The Composition and Classification of the Pa. Anthracites; Amer. Inst. Min. Eng. Feb. 1886.

Second Report Progress Anthracite Sur. Part II, 1885.

The Geology of the Brandywine Summit Kaolin Deposits, 1885.

The Wyoming Valley Limestones and their Geology; Wyo. Hist. & Geol. Soc. 1885.

Description of the Quaternary Geology of the Wyoming-Lackawanna Valley, 1885.

The Geology of the Tipton Run Sub-Carboniferous Coal Basin, Blair Co. Pa. 1885.

Description of the Wyoming Valley Limestone beds; An. Rep. Geol. Sur. of Pa. 1885.

Composition of Anthracites; Science, 1884.

The Geology of Carbon Co. Pa.; Hist. of Carbon Co. 1884.

Brief Description of the Anthracite Coal Fields of Pa.; Eng. Club, Phila. June 1884.

The Geological Distribution of Natural Gas in the United States; Amer. Inst. Min. Eng. 1886.

Three statistical Charts showing the History and Development of the Oil Regions of Pa., and N. Y. 1859-1880; Rep. on Petroleum; 10th U. S. Census.

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Natural Gas Explorations on the Ontario Peninsula; Amer. Ins. Min. Eng. Vol. XVIII.[4]

THE LOWER AND MIDDLE TACONIC OF EUROPE AND NORTH AMERICA.

By JULES MARCOU, Cambridge.

II.

Norway.—I have given previously the classification of professor Brœgger for the *Paradoxides* beds of Norway. His "etage 1 b." having been placed in the *Holmia* zone or Scandinavian, we have left for the Bohemian formation only his "etages 1 c and 1 d," in which are found at Krekling, Styggedal, Œxna, Tunsaosen, and Finden, the following fossils: *Paradoxides tessini*, *Par. rugulosus* and *Par. forchhammeri*, *Dolichometopus succicus*, three *Liostracus*, *Conocoryphe sulzeri*, *Elyx*, three *Solenopleura*, *Conocephalites*, two *Anomocare*, *Ellipsocephalus*, two *Arionellus*, fourteen *Agnostus* with seven varieties, an *Orthis*,

[4]He corrected the proof of this last paper on his death bed.

Lingula, *Obolella*, two *Acrothele*, *Acrotreta*, three *Hyolites*, a *Gasteropod* and a *Protospongia*. The Norway Bohemian formation is characterized, like that in Sweden by the *Paradoxides* and its great number of *Agnostus* in the upper beds with the existence of *Orthis* at Krekling.

In his admirable paper: "Parallèle entre les dépôts siluriens de Bohême et de Scandinavie", Prague, 1856, Barrande has signalized the existence of a land barrier between Scandinavia and Bohemia; and more than once, he has called attention to the great difference between the Paradoxides faunas of Europe, saying that the faunas were as well defined and localized to special regions or provinces during the Taconic period as they are now in our oceans. A great truth, which all subsequent researches all over the world, has proved to be a most valuable law, applicable to all the periods through which our globe has passed, since life made its apparition on its surface.

British Isles.—The Bohemian formation or *Paradoxides* zone, was pointed out as existing in the British Isles as far back as 1850, by Barrande, when on a visit to the Museum of Practical Geology in London. A specimen of *Paradoxides*, not well preserved and fragmentary, without any label of any sort, but surely British, found by him in the Museum recently created by de la Bèche, Edward Forbes and Salter, led Barrande to assure the English geologists, that the primordial fauna existed some where in their country. Is it not strange, that English pride of having the right to name and classify the older Palæozoic rocks, to the exclusion of the discoveries made in all the other countries, as it was assumed at the Berlin International Congress of 1885, by the Director General of the geological survey Mr. A. Geikie, should have received such a helping hand, in in a rapid visit to one of their museums.

As soon as Barrande had called their attention to it, they began to look more carefully over their Lower Palæozoic rocks of Wales; and Salter more especially devoted many years in hunting for an English locality of *Paradoxides* when finally twelve years after Barrande's visit and valuable indication of the existence of the *Paradoxides* zone and of the primordial fauna in the British Isles, Salter had the good luck to find *in situ* at St Davids the "gigantic trilobite long looked for in Britian": *Paradoxides Davidis!* That discovery modified profoundly the English classification, which until then was

limited to the "Lingula flags of Wales" for the primordial, and even that much was also due to the visit and advice of Barrande, who truly discovered the primordial fauna in England.

My friend, the late J. W. Salter, has done excellent work notwithstanding his premature poor health and sad death, and he may be considered as the representative of Barrande in England. It was not until 1856, six years after the celebrated visit of Barrande to the different museums in November and December, 1850, that Salter first discovered *in situ* only two primordial fossils; *Oldhamia* in Ireland, and a head of a trilobite in the Longmynd group of Sedgwick. Previously small primordial trilobites, recognized as primordial by Barrande in 1850, had been collected accidentally in the *Lingula* flags ofthe Bangor district, and had been described by Salter in the Decades of the geological survey, and also before the British Association in 1852. But after the discovery of the St. David locality, then the primodial fauna of the British Isles was rapidly developed, thanks to the combined efforts of Salter, David Homfray, Dr. H. Hicks, Prof. R. Harkness, C. Callaway, C. Lapworth, Kinahan, etc. As Salter rightly says: "To him (Barrande) therefore belongs the whole credit of originating the term, and defining the fossil characteristic of this *Primordial zone* a group of rocks which grows in distinctness and geological importance day by day" (The Geology of North Wales, p. 245, London, 1866, in the 3d Vol. *Mem. Geol. Surv. Great Britain.*)

Salter in his "Catalogue of the collection of Cambrian and Silurian fossils," Cambridge, (England) 1873, 4to, divides the *Paradoxides* zone or Bohemian formation, into three sub-groups called:

a. Longmynd group.
b. Harlech or Bangor group.
c. Menevian group or Lower Lingula flags.

The superposition of those sub-groups is doubtful and many English geologists consider the Menevian group of St. David as contemporaneous with the Longmynd and Harlech groups of North Wales. The Menevian of southwestern Wales has been enclosed between the Longmynd and Harlech groups and the Festiniog group, more as an imaginative classification and nomenclature than the result ofdirect stratigraphic observation. For the three groups do not exist anywhere together; and we may consider the whole scheme as a precau-

tionary measure in order to control all future discoveries of primordial fossils in the area of Wales and vicinity. Very likely the Menevian is the homotaxis of the greater part of those ill-defined groups the Longmynd and Harlech.

The fossils of the Bohemian formation of Great Britain are: *Parad. harknessi*, *Par. davidis*, *Par. hicksii* and *Par. aurora*,one *Conocoryphe* or *Conocephalites*, two *Microdiscus*, one *Arionellus*, *two Anopolenus*, and three doubtful *Olenus?* one *Holocephalina*, a *Plutonia*, ten *Agnostus*, four *Primitia* and one *Hysnenocasis; Discina*, three *Oboleta*, *Lingulella*, one *Orthis*, five *Theca*, *Stenotheca*, *Cyrtotheca*, two *Oldhamia*, two *Protospongia* and one *Cyrtidea*. As a whole the British Bohemian fauna, although related to Barrande's fauna of Bohemia, had more affinities with the Bohemian fauna of Sweden and Norway. The *Agnostus* is very abundant in the uppermost part of the formation, as it is in Norway.

France.—It was not until 1888, that a patch of the Bohemian formation or *Paradoxides* zone was found at Ferrals-les-Montagnes, Hèrault, in France, by M. Jules Bergeron. That locality of the "Montagne Noire," northeast of Carcassone, in Languedoc, presents a small outcrop of red, yellow, and green slates only 36 feet thick, containing a *Paradoxides*, one *Arionellus*, two *Conocephalites*, and several species of *Agnostus* ("Faune primordiale-Paradoxidien-dans les environs de Ferrals-les-Montagnes [Hérault]," in *Bulletin Soc. Géol. France*, vol. xvi, p. 282, Paris). From the scanty notes published so far, we may infer that the Ferrals primordial fauna, shows affinities and relationship with the faunas of Bohemia, Sardinia and Spain, and they seem to indicate that it belongs to the same Middle Taconic province, which may be called Asturio-Bohemia province; as the province of England, Norway and Sweden may be called Scanio-Wales province, making two distinct zoological provinces in Europe for the *Paradoxides* zone or Bohemian formation.

Sardinia.—To the northwest of the town of Iglesias, between Malfid and Masua, and at Canalgrande (See *Carta geologica d'Italia*, scale 1:1,000,000, in two sheets, published by the geological survey of Italy, Roma, 1889), on the sea shore there are several outcrops of fossiliferous primordial rocks. The classification of strata have not yet been given with all the details required for a complete understanding of the strat-

igraphy; and the late professor G. Meneghini has made use provisionally of a general division in two parts ("Palæontologia dell' Iglesiente Trilobiti," in *Mem. della carta geologica d'Italia*, vol. III, Firenze, 1886). Mr. J. G. Bornemann has published also at Halle, in 1886, his "Die Versteinerungen der Cambrischen Schichten systems der Insel Sardinien."

These two important paleontological works enable us to say with certainty that the *Paradoxides* zone or Bohemian formation is well represented in Sardinia. Very likely a part of the Upper Taconic, more especially the *Olenus* zone, exists also there. Further detailed sections and close research for fossils will further develop the first discovery of the primordial fauna, made, as far back as 1857, by the late general Alberto de la Marmora in the island of Sardinia. Meneghini has described 3 *Paradoxides*, 6 *Conocephalites*, 2 *Conocoryphe*, 1 *Liostracus* and 5 *Anamocare*; besides 5 *Olenus* which seems mixed in the same beds with *Paradoxides*, an abnormal association which requires to be carefully looked after, before being accepted as an indisputable fact.

Spain.—In 1859, Casiano de Prado, found the *Paradoxides* zone north-east of Leon, between Sabrero and Boñar ("Sur l'existence de la faune primordiale dans la chaine Cantabrique;" *Bulletin soc. géol. France*, vol. XVII, p. 516, Paris, 1860). Barrande and de Verneuil published the fossils found by de Prado, and here is the list: *Paradoxides*, *Arionellus*, 3 *Conocephalites*, 2 *Agnostus*, *Leperditia*, *Capulus*, *Discina*, *Orthis*, *Orthisina* and a Cystidean. Barrande insists on the great analogy of the *Paradoxides* zone of the Cantabric chain with the one of Bohemia; three species of trilobites being identical.

In 1882, M. Charles Barrois published his geological studies and researches on the Asturias, a very remarkable and valuable work entitled; "Recherches sur les terrains anciens des Asturies et de la Galice," p. 168, etc. in *Mém. Soc. géol. Nord*, vol. II. Lille. M. Barrois has recognized the *Paradoxides* zone or Bohemian formation at la Vega, Rivadeo and Pont-Radical. His list of fossils, several of which are new species, gives the following Bohemian forms: 2 *Paradoxides*, 3 *Conocephalites*, *Arionellus*, *Trochocystites*, and some Brachiopoda badly preserved.

The *Paradoxides* zone has been signalized, 1874, by Mr. F. M. Donayre, in the province of Saragoza. We know also that

the Taconic system exists in the provinces of Ciudal-Real, Caceres, Andalusia, Grenada, Alemtejo (Portugal) and Tras os Montes (Portugal), but further researches are wanted before a final classification of the different patches in Spain and Portugal may be properly attempted.

Newfoundland.—Resuming the stratigraphic researches of Messrs. Howley and Murray, and the paleontological works of Messrs. Billings, Whiteaves and himself, Mr. G. F. Matthew, in his interesting paper, already quoted, "Cambrian faunas of Newfoundland" pp. 149-151, gives the following sub-divisions of the *Paradoxides* zone:

A.—Horizon of Agraulos strenuus.——Holmia Zone.
B.——id.——of the Conocoryphinæ.—Paradoxides—id.—
C.——id.——of Paradoxides spinosus. —id.—— —id.—
D.——id.——id. ——id.—— tessini.————id.—— —id.—
E.——id.——id. ——id.—— davidis.——id.—— —id.—
Fauna of Olenus division of Kelly's island and Great Bell island.

As we have seen before, division A contains *Holmia* (*Paradoxides?*), and belongs to the Scandinavian formation or *Holmia* (*Olenellus*) zone. There remains only four sub-divisions B, C, D and E, of *Paradoxides* beds. They are all situated in St. Mary's, Conception and Trinity bays, in the south-eastern part of Newfoundland.

What Mr. Matthew calls "fauna of the Olenus division" from Kelly's island and Great Bell island, is so far very limited and rather meagre, but further researches may develop it. At Bell island Mr. Howley has found a large trilobite, undetermined, rather rare; and the other fossils quoted by Mr. Matthew: *Eophyton*, *Arthraria*, *Lingula*, *Lingullella* and *Cruziana*, are all old forms.

Mr. Howley in his column of primordial strata, calls the *Paradoxides* beds of St. Mary's and Conception bays, division *n*. Then *o*. and *p*. designate a limestone of Highland cove (Trinity bay) with *Paradoxides*; and divisions *q*, *r*, *s*, show the thick formation of Kelly's island and Bell island of Conception bay, just spoken of in the preceding paragraph.

According to Mr. Matthew, the *Paradoxides* zone fauna of his divisions B., C., D. and E., is composed of 5 *Paradoxides*, 3 *Microdiscus*, 3 *Conocephalites*, *Agraulos*, *Selenopleura*, *Anopolenus*, *Centropleura* and 12 *Agnostus*, *Hyolites*, *Obolella*, and *Eocystites*. All these are forms of the Bohemian formation of England, Norway and Sweden. The similarity of the fossils

of Newfoundland is such that southeastern Newfoundland may be placed in the north Neutral Homozoic Band of the Middle Taconic period. In Newfoundland the sediments are much thicker than in Scandinavia; even more so than in Wales.

Mr. Walcott has added a few fossils, more especially trilobites, found by him at Manuel brook in Conception bay, such as *Paradoxides hicksi*, *Ctenocephalus*, *Liostracus*, *Erinnys*, 2 *Ptychoparia*, *Holocephalina*, *Linnarssonia*, *Acrothela* and *Orthis*.

The locality of Branch at St. Mary's bay, containing the great *Paradoxides bennettii* and *Agraulos affinis*, is very likely at the base of the *Paradoxides* zone, like the Braintree *Paradoxides* beds of Massachusetts, and also Band *c*. of division 1 of the St. John group of New Brunswick, called for Newfoundland by Mr. Matthew "B. Horizon of the Conocoryphinæ." Probably more minute and new search in St. Mary's bay will bring more fossils and throw more light on the lower horizon of the *Paradoxides* zone of eastern North America.

New Brunswick.—In 1862, many years after the discovery of the Paradoxidean fauna by Dr. Emmons, and even several years after the discovery of the Braintree *Paradoxides* and the St. Mary's bay *Paradoxides*, Rev. C. R. Matthew, found Paradoxidean trilobites near and even in the town of St. John, New Brunswick. My lamented friend, the late Frederick C. Hartt, determined and described the fossils collected by the two Messrs. Matthew and himself in 1865 and 1868. Afterward Billings added a few species; and finally Mr. G. F. Matthew, since 1877, has made extensive collections round St. John, and has published important stratigraphic and paleontologic memoirs, so that he has made St. John the typical locality for the *Paradoxides* zone or Bohemian formation of eastern North America, and one of the most important regions in the world.

Since Barrande's admirable studies on the primordial trilobites, nothing so important and so thorough, has been published as Mr. Matthew's remarkable "Illustrations of the Fauna of the St. John Group," in four parts, 1882-1887, 4to in the *Trans. Roy. Soc. Canada*. The works of Mr. Matthew are of the first order, and place him at the head of American paleontologists, for the Lower Paleozoic. I am glad to have an occasion to express my admiration for the excellent work he is doing, on account of our divergence in the use of names for

the nomenclature of the strata containing the primordial fauna. As a true English geologist, with a patriotic leaning ([1]), intensified by his stay in a colony of the British crown, Mr. Matthew adheres to the word Cambrian—not the primitive Cambrian of Sedgwick, but a lately made up Cambrian—for the name to be given to all the strata containing the primordial fauna, against plain facts of priority in favor of the name Taconic, first used by American geologists, as far back as 1844 and 1842, many years before the discovery of the primordial fauna in. the British Isles and in all the British colonies. Barrande was more just, for as soon as he was acquainted with Dr. Emmons discoveries, with a true scientific and liberal spirit, he did not hesitate to publish his complete adhesion to them and to proclaim that an American geologist had discovered first the primordial fauna and the Taconic system in which it is located. But Barrande had a cosmopolitan and widely open mind, and a sense of justice very rare among geologists and paleontologists.

Mr. Mathew divides his "Series 1. B.—the St. John group," which represents in New Brunswick the Bohemian formation or *Paradoxides* zone, into four bands or assises *a. b. c.* and *d.* The fossils are: 6 *Paradoxides*—one species the *Parad. eteminus* has four varieties, and another one the *Parad. regina* in honor of her majesity, Queen Victoria, is the largest sized *Paradoxides* yet found—*Ellipsocephalus*, 2 *Solenopleura*, *Ptychoparia*, 2 *Liostracus*, 3 *Agraulos*, 2 *Conocoryphe*, 3 *Microdiscus*, 8 *Agnostus* with four varieties; *Primitia*, 2 *Beyrichona*, *Hyponicharion*, *Lepidilla*, 2 *Lepiditta*, *Harttia*, 6 *Stenotheca*, 2 *Diplotheca* with four varieties, 3 *Hyolites*, 2 *Orthis*, 2 *Kutorgina*, *Acrothele* with two varieties, 2 *Acrotreta*, 2 *Linnarssonia*, 3 *Lingulella*, *Eocystites*, 2 *Hydrozoa* or *Graptolites*, *Eocoryne*, *Protospongia* and

([1]) It is extremely difficult for English geologists to accept and use nomenclature made outside of their islands. I remember forty-five years ago, how they were opposed to the use of the names Jura and Jurassic system, instead of Oolite and Oolitic system. It took three and four generations before they were reconciled to that beautiful name of Jurassic series. The Trias also was strongly opposed as a name, because it originated in Germany. As to Dyas instead of the wrongly created Permian, it begins only now to be used, notwithstanding the long admitted error of Murchison, who confounded the whole Russian Trias with the Zechstein and Rothliegende. So we must expect a long opposition by English geologists to the use of the American name of Taconic; and very likely it will take five or six generations before they come to it.

Archæocyathus, a most complete and very important fauna of the *Paradoxies* zone.

Braintree, Massachusetts.—The Bohemian formation of Braintree near Boston, was classified as such by Barrande in 1860. The species of fossils are few, being confined to *Paradoxides harlani*, a very large trilobite closely allied to *Parad. spinosus* of Bohemia and to *Parad. bennettii* of Newfoundland, 1 *Ptychoparia*, an *Arionellus* or *Agraulos* and a *Hyolites;* only four species. It represents the same horizon as the beds of Branch on the St. Mary's bay, Newfoundland, and belongs to the lowest horizon of the *Paradoxides* zone.

Nevado-Canadian Lower and Middle Taconic.—Now that we have reviewed all the outcrops of the Lower and Middle Taconic strata of the Acadio-Russian sea, and have tried to give a clear and exact classification and nomenclature in four great formations or groups, we shall describe and compare the patches of Lower and Middle Taconic existing in the Nevado-Canadian sea, the original region of the Taconic system and the first place in the world where the primordial fauna was found and described as the oldest fauna existing below the Cambrian fauna of Wales.

Tabular view of the Lower and Middle Taconic of the Nevado-Canadian sea.

IV. Georgia formation or Elliptocephalus (Olenellus) zone.
III. and II. St. Albans formation.
I. Chuar formation of the Grand Cañon of the Colorado.

Original Taconic area.—The Acadio-Russian sea of the Taconic period, was separated from the Nevado-Canadian sea by a long isthmus extending from the eastern coast of Labrador to Rhode Island and southeastern Massachusetts. At two points the isthmus was very narrow and can be compared with the present isthmus of Panama and Tehuantepec. The first place was between Canada bay in the extreme northeastern part of Newfoundland and Bonavista bay, southeastern Newfoundland, a distance of 150 miles; and the second point was between Braintree near Boston and Attleborough near Providence, Rhode Island, a distance of only 35 miles.[1] At Bonavista bay and at Braintree, we have slate deposits of the argillite lithological type, containing *Paradoxides* and conse-

[1] The *terra firma* on the "Physical Sketch-map" as frontispiece of this paper, in the June number American Geologist, Vol. V, p. 357, is too broad between Braintree and Attleborough, Massachusetts; it ought to be reduced to a single line. It is an error of the engraver.

quently of the *Paradoxides* zone; and at Canada bay and at Attleborough we have the fauna of the Georgia formation or *Elliptocephalus (Olenellus)* zone, different as regard species, and even forms of the trilobites form the fauna of the Bohemian formation. We have on the two sides of that great isthmus two faunas which can be parallelized and are at least partly homotaxical.

The deposits of strata on each side, are quite different lithologically, although having in common the slaty characters of the principal masses of rocks. In the Acadio-Russian sea the slates and argillites contain, very seldom, limestone nodules or very small limestone lentilles, called *Kalkboller* at Krekling in Norway and *boulder-like masses* at St. John, New Brunswick, of extremely limited dimensions, varying in size from nodules of only one inch across, to elliptical masses of about a yard in diameter, while in the Nevado-Canadian sea the slates inclose great lenticular masses of limestone, generally more or less dolomitic; which vary in dimensions from the size of a man's head to knobs of prominent spherical masses of fifty yards and even more in diameter, as round St. Albans, in Vermont, or elongated lenticular masses from twenty-five yards long to one thousand yards and even more, as we find them at Phillipsburgh, Highgate falls, Pointe-Lévis, Bic harbor, and in many places in Vermont, New York, Massachusetts and Rhode Island. The importance of the deposits in the Nevado-Canadian sea is due, not only to their great thickness and their peculiar lithology, but also and mainly because, it was while studying them that by a stroke of genius Dr. Emmons recognized that they belonged to an older system, than any known until then, and that they were characterized by a special fauna, totally different from the faunas previously discovered and signalized in Europe and America. It was a gigantic step, which displaced the base of the Paleozoic strata, carrying it down twenty-five thousand feet lower than Sedgwick and Murchison had done by their researches in England and on the continent of Europe.

These discoveries of Dr. Emmons were made from 1838 to 1844, and published, first in his "Final Report of the second district of New York" (Jan. 1, 1842), and finally in 1844, in "The Taconic system, etc." Two years later Barrande in his "Notice préliminaire sur le systēme Silurien et les trilobites de

la Bohême," p. 9. Leipzic, 1846, insisted on the complete independence of the fauna of his inferior division C, and according to the happy expression used by d'Omalius d'Halloy, Barrande "created the primordial fauna." Then Barrande did not know Emmons' discoveries but as soon as he got hold of Emmons' publications, he disavowed all claims of priority, and with his great honesty and courtesy, he said: "I fear that some one may attribute to me the merit of priority which I am far from pretending," * * * "it is clear that Dr. Emmons has first announced the existence of a fauna anterior to that which has been established in the *Silurian system* as characterizing the Lower Silurian division and which I have named second fauna. It is then just to recognize this priority, and I think it all the more fitting to state it at this time, that it has not been claimed to this day" ("Documents anciens et nouveaux sur la faune primordiale et le système Taconique en Amerique," in *Bulletin Soc. géol. France* tome, XVIII, p. 225, Paris, 1861.)

After Barrande's noble words and the continual discoveries of the primordial fauna in the Taconic strata of North America, the "cardinal principles of geologic nomenclature, 1, priority of definition, and 2 accuracy of the original observations" as they are called by a recent writer, will forcibly one day or another, lead all geologists to use the name Taconic, in the general classification of the world. It is only a question of time and justice, and in geology time is everything, as to justice it will come as a consequence of truth against all national prejudices and interested oppositions.

Dr. Emmons' classification of the Taconic strata, in the original Taconic area of western Massachusetts and eastern New York, comprises five divisions, two of which belong to the Upper Taconic *b* and *d*, and the three others *a*, *c*, and *e* to the Middle and Lower Taconic. In the "Granular quartz" or division *e*, we have a small fauna indicating that it is very likely contemporary and homotaxical of the Scandinavian formation or *Holmia* zone of Europe. Only three fossils have been found yet in it, two miles east of Bennington, Vermont, a *Nothozoe*, a *Hyolites*, and a trilobite called *Olenellus thompsoni* by Mr. Walcott. As no figure, nor description of any sort of the trilobite has been given, except the few words: "heads of a species of *Olenellus* undistinguishable from *O. thompsoni* of

the Georgia formation in Franklin county, Vermont," ("The Taconic system of Emmons, etc." in *Amer. Jr. Sc.*, vol xxxv, p. 234, 1888); it is impossible to say what sort of trilobite it is. Mr. Walcott's determination of *Atops trilineatus* Emmons, as identical with *Triarthrus beckii*, his belief that *Elliptocephalus* (*Olenellus*) *asaphoides* is "generically identical with *Holmia kjerulfi* and *Schmidtia mickwitzi*," and also his reference of the original *Microdiscus quadricostatus* Emmons to *Trinucleus concentricus*, saying that "we now know that the light colored fragile shales of Augusta county, Virginia, belong to the Hudson River group," are examples too conspicuous of his way of identification of species and genera, and determination of age of strata to enable us to accept his conclusions, without the most positive documents, with good figures and accurate descriptions. His extraordinary announcement that *Olenellus* (*Elliptocephalus*) *thompsoni* was found ranging in 14,000 feet of strata in New York and Vermont, is another suspicious discovery which requires to be controlled by reliable stratigraphic observations before being accepted. It is best to regard his *O. thompsoni* of the Granular quartz of the vicinity of Bennington, as not identical with the trilobite of Georgia, but as a Paradoxidean form, which may belong perhaps to *Holmia* or to *Schmidtia*. In such cases we may have the Scandinavian formation, or even perhaps the Esthonian formation of Europe. Further researches are necessary before reaching final conclusion.

Provisionally regarding the division *e*, Granular quartz of Emmons, as Lower Taconic and the homotaxis of the Esthonian formation, his division *c* Magnesian slate, and *a* Black slate, belong with certainty to the Middle Taconic or Scandinavian and Bohemian formations; because in them are found the true primordial fauna of the Georgia formation of Vermont. The list of fossils in the original Taconic area, for the vicinity of Bald mountain (the first place in the world where the primordial fauna was recognized as a special fauna), the vicinity of Troy, Dutchess county, etc., is: *Atops*, 2 *Elliptocephalus*, (*Paradoxides* of Barrande; *Olenus*, *Barrandia* and *Olenellus* of Hall), *Pagura*, 4 *Microdiscus*, *Ptychoparia*, *Solenopleura*, *Olenoides*, 3 *Agnostus*, 2 *Leperditia*, 6 *Hyolites*, *Platyceras*, *Stenotheca*, *Scenella*, *Fordilla*, *Orthis*, 3 *Obolella*, *Lingulella*, *Kutorgina*. *Linnarssonia*; all representative species of forms most characteristic of the *Paradoxides* zone or Bohemian for-

mation of Bohemia, Scandinavia, England, Newfoundland and New Brunswick.

Vermont.—At West Georgia, Vermont, in the vicinity of St. Albans, the primordial fauna was accidentally discovered by a farmer, Mr. N. E. Parker, fifty yards from his house and referred by Messrs. James Hall, Logan and Hitchcock to the Hudson River group, or even to a special group above it. Barrande seeing that this singular and curious stratigraphical position given to his primordial fauna, would involve a transfer above the second fauna, and consequently break down his record of good observer, as well stratigraphically as paleontologically, begged me repeatedly to go there and make the stratigraphical section. This was done in 1861 and 1862; and my classification on the succession and true stratigraphic position of the Taconic or primordial faunas in America, is the first systematic arrangement of the formations containing them, that was made and published on the basis of the paleontological determinations of Barrande, and against the extraordinary stratigraphic and paleontologic views of Hall and Logan.

Here is the order of succession, as I published it in 1861 and 1862. [1]

Table of the Taconic of Vermont (Proceed. Boston Soc. Nat. Hist., vol. VIII, p. 241, 1861.)

Potsdam sandstone 300 to 400 feet. *Conocephalites.*
Lingula flags 500 to 600 feet. *Lingula, Orthisina, Orthis, Graptolites.*
Georgia slates 500 to 600 feet. *Paradoxides (Olenellus) thompsoni, Peltura, Conocephalites, Obolella, Orthisina, Camerella.*
St. Albans group 2500 to 3000 feet. Tribolites undetermined.

Table of the Taconic in Vermont (Letter to M. J. Barrande on the Taconic, p. 4. Cambridge, 1862.)

Potsdam sandstone 300 feet. *Conocephalites* and *Obolus.*
Swanton slates 2000 feet. *Graptolites.*
Phillipsburgh group 1500 feet. *Dikelocephalus, Bathyurus, Camerella* and colonies of second fauna.
Georgia slates 400 feet. *Elliptocephalus (Olenellus) thompsoni, Conocephalites, Obolella, Orthisina, Camerella.*
St. Albans group, 5,000 feet, with roofing slates and granular quartz.

(1) Mr. C. D. Walcott in his two papers: "Second contribution to the studies on the Cambrian faunas," pp. 12 and 13, Washington, 1886, and "Stratigraphic position of the Olenellus fauna in North America and Europe," *Amer. Journ.*, vol. XXXVII, p. 374, New Haven, 1889, passes over my observations and published tables of the succession of the Taconic fauna, as if they did not exist; and refers, against dates and all right of priority, the first systematic arrangement of the groups or formations containing them, to Logan in 1864, three years after my table of 1861, and to Messrs. Dana (1881), Whitfield (1885) and T. Sterry Hunt (1884), a very incorrect and partial review.

The Georgia slates represent the Bohemian formation of the Acadio-Russian sea, or *Paradoxides* zone with its characteristic fossils, such as, *Elliptocephalus* (*Olenellus*) *thompsoni*, 2 *Protypus*, 2 *Conocephalites* (*Ptychoparia*), *Olenoides? Mesonacis*, *Peltura* (*Bathynotus*), *Solenopleura*, *Agnostus*, *Salterella*, *Hyolites*, *Scenella*, *Orthisina*, *Camerella* (*Kutorginæ*), and two *Graptolites*. I have not signalized sooner the existence of *graptolites* in the Middle Taconic, although it was first recognized by Dr. Emmons, and Mr. Matthew has found one species at St. John, because that rather problematic and very low organism has been used too freely, and the consequence has been on the part of the adversaries of the Taconic system, a confusion in the classification of the great Taconic slaty rocks, with the Utica slates and Lorraine shales. More careful studies of the forms and more strict stratigraphical determination for their *habitat*, are required before we can know their value in the classification of strata.

The St. Albans group was created to place in it all the strata existing between the band of the Georgia slates or formation in Franklin county, Vermont, eastward of Parker's farm outcrop, and the talcose slates and conglomerates of Fairfield. Although there have been reports that large tribolites have been found in two places, east of St. Albans village and Highgate Falls village, no specimens have ever found their way into the hands of paleontologists, or reliable practical geologists The thickness of five thousand feet is very likely less than the truth; and in that great mass of stratified rocks, fossils, although rare, can be found when they are carefully explored by fossil collectors and resident stratigraphists.

In the St. Albans group, near the base, in the vicinity of the Georgia railroad station, true argillite slates are found, as at Braintree and St. Mary's bay, and there is no reasonable doubt that one day or another primordial fossils and more especially large trilobites of Paradoxidean forms will be found in the St. Albans group of Vermont, Canada and Maine. It is a question of time. But now, already, we can consider the St. Albans group as representing stratigraphically and lithologically all the lower parts of the *Paradoxides* zone containing the large *Paradoxides*, such as *Paradoxides harlani*, *Par. regina*, *Par. bennettii*, and *Par. davidis*, and also the *Holmia* zone and even the *Schmidtia* zone.

The upper part of the *Paradoxides* zone, is represented without any possible doubt, by the Georgia formation or *Elliptocephalus* (*Olenellus*) zone. The very learned and excellent observer, professor W. C. Brœgger of Stockholm, has published a paper on the position of the *Olenellus* zone, in North America, ("Om alderen af Olenellus zonen i Nord Amerika," Stockholm, 1886) based on the erroneous classification used by the adversaries of the Taconic system. If professor Brœgger had not attributed several of our groups of strata to the Lower and Middle Potsdam, with which they have no relation whatever, he would have come to different conclusions. His *Olenellus* (*Holmia*) zone of Scandinavia, is well represented as he says in Newfoundland. But the Georgia formation with its original *Elliptocephalus* (*Olenellus*), contains all the forms of fossils of the upper part of the *Paradoxides* zone of Scandinavia, and is the homotaxical fauna of the divisions: *a* beds with the *Agnostus lævigatus*, *c* beds with *Paradoxides forchhammeri* and *c* beds with *Agnostus lundgeri* of Messrs. Tullberg and Nathrost's classification of Scania. Several of the forms of the fossils of Georgia are prophetic types and are the "avant-coureurs" as Barrande says, of the forms of fossils which develop in the supra-primordial fauna; such is the case with *Olenoides? marcoui*, *Orthisina*, *Fordilla*, *Leperditia*, *Platyceras*, and *Pleurotomaria* (*Raphistoma*); no one of which is found in the Scandinavian formation or *Holmia* zone. Many confusions created by the ever changing and always incorrect classification of the adversaries of the Taconic system, would have been avoided by professor Brœgger, if he had not accepted as correct the tables of strata published at different times by Messrs. Hall, Ford, Whitfield, Walcott and the Geological surveys of Canada and Newfoundland.

The synchronism between the strata of the Taconic system deposited in the Nevado-Canadian sea, and those deposited in the Acadio-Russian sea, can be made only by homotaxical faunas and a reasonable allowance for stratigraphical positions.

The St. Lawrence gulf and the vicinity of Quebec city.—The upper portion of the Middle Taconic or Georgia formation is found in several localities of northeast and western Newfoundland, from Canada bay, Belle isle Strait, to Port-à-Port bay, with its characteristic fossil the *Elliptocephalus* (*Olenellus*) *thompsoni*.

In the province of Quebec, on the south shore of the St. Lawrence river, from Bic Harbor, Notre Dame du Portage, St. Denis, St. Roch, St. Jean, L'Islet, Canoe Island to the vicinity of Beaumont near Point Lévis, we have a fine belt of the Georgia formation or *Elliptocephalus* (*Olenellus*) zone, containing the whole fauna of Georgia, as well developed as in Vermont. As far back as 1862, in my "Letter to M. Joachim Barrande, on the Taconic rocks of Vermont and Canada," with "comparative tabular sections of the Upper Taconic rocks of Vermont and Lower Canada" p. 10, Cambridge, I have classified a group 400 feet thick, which I called "Redoute group," containing a purely primordial fauna, with the Georgia formation. In 1864, I published a very detailed plan of the lenticular masses inclosed in slates at Point Lévis ("Notice sur les gisements des lentilles trilobitifères taconiques de la Point Lévis au Canada," *Bul. Soc. Géol. France*, vol. XXI, p. 236, Paris), with a slight change, saying that " The Georgia slates have not yet been recognized with certainty in that region"; and I gave the following classification:

Quebec city group, 2,400 feet.
Point Lévis group, 1,400 feet.
Chaudière and Sillery group, 3,000 feet.

Saying at the same time, the Georgia group is probably situated between the Pointe Lévis and the Chaudière and Sillery groups. The discoveries made since by the Geological Survey of Canada of the Georgia formation with *Elliptocephalus* (*Olenellus*) *thompsoni* at L'Islet, Canoe Island and above Beaumont, in close proximity to Pointe Lévis show that my supposition was correct.

What Dr. Ells calls his Sillery group. (*Ann. Report Geol. Sur. Canada*, 1887-88, vol. III, part II, K. 1889), is composed of two divisions, the Upper and Lower Sillery. This Upper Sillery is simply the Georgia formation presenting different facies of the typical Georgia slates of Vermont, on account of an eruption of dioritic or porphyritic trap (a true diabase) in the area of La Chaudière and Etchemin rivers. In that peculiar facies the *Elliptocephalus* (*Olenellus*) *thompsoni* and other fossils of Georgia are scarce, and when no lenticular masses of limestone are found, the slates of both groups, Sillery and Pointe Lévis are confounded in one single mass of shales, red, greenish, greyish, blackish, with a few limited bands of quartzite and calcareous sandstone,

which it is impossible to divide into groups. However the beds containing the *Obolella pretiosa* may be regarded as the upper horizon of the Chaudière and Sillery groups, and the junction beds of the Sillery with the Pointe Lévis. According to my observations and views, what Dr. Ells calls "Upper Sillery" represents the Georgian formation in the close vicinity of Quebec city and at Pointe Lévis, ([1]). Here is my classification of the great slaty masses and limestone in the province of Quebec.

Tabular view of the stratigraphy of the province of Quebec.

Champlain of Emmons, or true Cambrian of Sedgwick or Lower Silurian of Murchison.	UTICA SLATES, from Rouse's Point to St. John lake, with tongues or narrow stripes resting on the Upper Taconic slates of the Citadel Hill and Swanton group, by landslides along the line of contact of the Trenton with the Taconic slates. TRENTON, including Black River group, above Montmorency falls and other localities. CHAZY AND CALCIFEROUS, represented eastward after passing Chico creek by a conglomerate made up of rolled pebbles of the underlying quartzite, several feet in thickness.
———————	Break.
	No Potsdam was deposited round the city of Quebec.
———————	Break.
Upper Taconic or Bathyurus and Dikelocephalus zone.	CITADEL HILL AND QUEBEC CITY OR SWANTON SLATES; with precursory centers of the second fauna, contained in lenticular masses of limestone at Quebec city and at Highgate spring, (Vermont.) POINT LÉVIS AND PHILLIPSBURGH; with colonies or precursory centers of the second fauna, contained in lenticular masses at Pointe Lévis and at Phillipsburgh.
Middle Taconic or Elliptocephalus zone.	GEORGIA OR UPPER SILLERY; or *Elliptocephalus* (*Olenellus*) belt, with *Obolella pretiosa* round Quebec, and *Elliptocephalus* eastward from near Beaumont to Bic Harbor.
Lower Taconic.	Chaudière or Lower Sillery, corresponding in part with the St. Albans group of Vermont.

Dr. Ells, his assistants Messrs H. M. Ami, N. J. Giroux, and St. Cyr, Director Selwyn and Mr. C. D. Walcott, have given as

[1]The Point Lévis group although synchronized with the Phillipsburgh group, on account of fourteen common species of fossils, is in reality a little older and is the equivalent of the slates at the base of the Phillipsburgh lenticular masses of limestone, which extend all over the narrow valley of the village of St. Armand between the most eastern lenticular limestone and the Georgia formation belt.

the result of their joint researches, the following classification, which I résumé in a tabular view, in order to make it clear to the reader.

Cambro-Silurian of Messrs. Selwyn and Ells, or Ordovician of Mr. Walcott. The Champlain of Emmons.	LORRAINE SHALES, at St. Nicolas and St. Croix 12 miles above Pointe Lévis and Quebec city, Messrs. Giroux and Ami refer all the slates, between Charlebourg and Indian Lorette, to Ste. Foix and the Tower No.4 between"côte de la négresse and côte Sauvageau" to the Lorraine shales or true HudsonRiver sediments, with a thickness of at least 4,000 feet. No fossils are given for the area between Quebec city, Ste. Foix, Lorette and Charlebourg. UTICA SLATES at the mouth of the river Montmorency with *Thiarthrus beckii* common; and at the eastern side of the foot of Montmorency falls.[2] TRENTON LIMESTONE, at Pointe aux Trembles, Ancient Lorette, Beauport, and Montmorency, with a Black River facies in their lowest portion at Lorette and Montmorency. ——Fault North of the city of Quebec, at the great escarpment, west of Tower No. 4. QUEBEC CITY ROCKS. The exact horizon of the citadel rocks is still to some extent doubtful. According to professor Lapworth, it is Lower Trenton, that is to say Black River group; and Dr. Ells calls it a peculiar development about the age of the Trenton formation. LÉVIS FORMATION, referred by Dr. Ells to the Lower Ordovician or Cambro-Silurian (lower Champlain of Emmons); and by Mr. Walcott to the Calciferous age.
Cambrian of Messrs. Ells and Selwyn. Lower portion of Ordovician and the Lower Cambrian of Mr. Walcott.	SILLERY FORMATION, divided into "Upper Sillery" with *Obolella pretiosa* and "Lower Sillery" by Dr. Ells, who refers both of them to the Cambrian (Taconic). Mr. Walcott includes the Upper portion of the Sillery beds in his Ordovician (Champlain) above the typical Potsdam of New York, and he is inclined to think that the Lower series of the Sillery is the source from which the "limestone conglomerate[3] of the Lévis was derived which contains the *Olenellus fauna*"

[2]At both places the Utica slate lies in discordance of stratification on the Taconic slates of the citadel and Quebec city group. By combined erosion and denudation, a patch of lower Utica and upper Trenton has slipped over the fall, and a tongue of Utica slate has been preserved at the actual mouth of the Montmorency river in the St. Lawrence. Careful observations at Montmorency, Lorette, Quebec city, will convince every practical geologist of the occurrence of landslides in the whole area, from the moment that it become dry land or *Terra firma*,

Table showing the correlations of the classifications and nomenclatures according to the observations of Messrs. Selwyn, Ells, Walcott and Marcou.

<table>
<tr><th colspan="2">Marcou, 1862.</th><th colspan="3">Selwyn and Ells, 1889.</th><th>Walcott, 1890.</th></tr>
<tr><td>Champlain System.</td><td>Utica Slates.
Trenton.
Chazy and Calciferous or quartzites conglomerate.</td><td>Cambro-Silurian.</td><td colspan="2">Lorraine Shales.
Utica Slate.
Trenton with Black River, the lower beds are made up of recemented debris from the underlying gneiss.
Quebec city or Lower Trenton?
Levis formation or Calciferous.</td><td rowspan="3">ORDOVICIAN.—ORDOVICIAN.</td></tr>
<tr><td>Upper Taconic or Dikelocephalus and Bathyurus Zone.</td><td>Break.
No Potsdam.
Quebec City.
Pointe Lévis.</td><td colspan="3">No Upper Taconic, or Dikelocephalus and Bathyurus Zone.</td></tr>
<tr><td>Middle Taconic or Ellipto-cephalus Zone.</td><td>Georgia or Upper Sillery.</td><td rowspan="2">Cambrian.</td><td rowspan="2">Sillery</td><td>Upper Sillery.</td></tr>
<tr><td>Lower Taconic.</td><td>Chaudière or Lower Sillery.</td><td>Lower Sillery.</td><td>Lower Cambrian.</td></tr>
</table>

The divergences of classification are still very great, although some progress has been made for the nomenclature; the Geological survey of Canada having abandoned at last the incomprehensible term of "Quebec group." After many hesitations they have come to use my nomenclature of 1862, with the exception of the name Chaudière, for the principal divisions of the rocks of that area; using the names of Quebec city group, Pointe Lévis group and Sillery group; which allow greater precision and a better understanding of the grouping of strata. For the present the three preceding tables are sufficient to show how matters stand, and I shall reserve a more

until this day, as was proved last winter again by a landslide almost in front of the citadel.

[3]Dr. Ells speaks of "conglomerate limestone" referring more especially "to pebbles of conglomerate found in the conglomerates of the Lévis series." The so-called "limestone conglomerate" containing fossils at Pointe Lévis is not conglomerate at all, but a magnesian limestone with a sub-crystalline and fragmentary texture harder than ordinary limestone.

detailed account of the geology of the vicinity of Quebec city, for my future paper on: "The Upper Taconic of Europe and North America."

Rhode Island and Attleborough (Massachusetts.)—As far back as 1844, Dr. Emmons, with his extreme keeness of observation and a true prophetic sense of deduction as a practical geologist, in classifying the oldest stratified rocks, recognized his Taconic system in Rhode Island, about ten miles from Providence, saying that he found there "a fragment of the Taconic system" ("Agriculture of New York," vol. I, pp. 90-93, Albany, 1846.)

Lately Messrs. N. S. Shaler and A. F. Foerste have published a paper: "On the geology of the Cambrian district of Bristol county, Massachusetts, with description of North Attleborough fossils," in *Bull. Mus. Comp. Zool.* vol. XVI, No. 2, Cambridge, 1888, which is simply a confirmation of the old discovery and observations of Emmons. A new example among the many already signalized of the correctness and excellent views and exact classifications of the father of American palæozoic geology.

As usual with the adversaries of Dr. Emmons, who want to obliterate his record, and replace his right of priority by English nomenclature, notwithstanding the many years which have elapsed between the American and the British discoveries of primordial fossils, Messrs. Shaler and Foerste, not only have not used the national name of Taconic, but they have even neglected to quote the discovery of Emmons in Rhode Island, between Providence and Wrentham, Massachusetts, going so far as not to notice the well known reference of the stratified rocks of that little basin to the older paleozoic series. They say: "Various conjectures have been made as to the age of these deposits. They have been thought by one observer to resemble the Trias, while others, owing partly to their position, have assigned them to the Devonian age. Until I (Mr. Shaler) began my studies upon this district, the strata have afforded no fossils, and the determinations above noted were purely conjectural."

The determination of Emmons was not "purely conjectural," but based on lithology and stratigraphic position, being enclosed in a little basin of Primary rocks. The strata are formed of magnesian slates, inclosing lenticular masses of

limestone, exactly as in the original Taconic area, and the fossils found by Mr. Shaler—twenty in number—belong to the Georgia fauna, with identical species of those found by Dr. Emmons near Bald mountain in his original Taconic region, at Troy near Albany and at Bic Harbor on the St. Lawrence river. Here is the list of species: 2 *Obolella*, *Fordilla troyensis*, *Scenella*, 3 *Stenotheca*, *Platyceras*, *Pleurotomaria* (*Raphistoma*), 4 *Hyolites*, *Hyolitellus*, *Salterella*, *Aristozoe?* 2 *Microdiscus*, *Paradoxides walcottii* (is not a *Paradoxides* but the small head of *Elliptocephalus asaphoides* of Emmons), *Ptychoparia mucronatus* (is identical in every respect with *Atops trilineatus* of Emmons), and *Ptychoparia attleborenis*.

That such a fauna, so different from the Braintree fauna, should be placed below, by Mr. Walcott, the paleontologist of the United States Geological survey, and synchronized with the *Holmia* zone or Scandinavian formation of Manuel's brook, is absolutely against all paleontological rules and against all our knowledge of Taconic paleontology ("Position of the Olenellus fauna, etc.," pp. 388-389, *Amer. Jr. Sc.*, vol. xxxvii, May, 1888.)

Alleghany area.—It is probable that the Middle Taconic or Georgia formation extends south from the eastern part of the state of New York, following the eastern base of the Alleghanies or Appalachian mountains. Indications of its existence have been signalized many years ago in Virginia by Dr. Emmons, and more recently by others in the states of Georgia, Tennessee and Alabama.

In Texas, strata older than the Upper Taconic, lie in discordance of stratification under beds which contain the supraprimordial fauna or *Olenus* zone. But until now no fossils have been found.

Rocky Mountain area.—The Rocky Mountain region promises to be one of the most important fields for the study of the Taconic system. The development attained by the series of Lower Paleozoic strata in the Grand Cañon of the Colorado, in the Wasatch mountains of Utah, in the Eureka district of Nevada, and in the Castle mountains (Canadian Pacific railway near the fifty-first parallel), show beyond any doubt, that we have in those areas a complete development of the Taconic system. Only we shall have to wait for further research before we can outline all the great divisions, and before we can find

the homotaxis deposits of all the formations we know now to exist in the Acadio-Russian sea.

Arizona.—In the Grand Cañon of the Colorado, below the supra-primordial fauna beds, called the "Tonto formation,' there is in discordance of stratification, a great mass of strata of sandstone, shales and limestones, 12,000 feet thick, which until now have given very few fossils. The difficulties of search, in such ravined and almost perpendicularly cut strata, so far removed from inhabited countries, combined with the sporadic character of the appearance of fossils during the whole Taconic period, are sufficient reasons for the scarcity of the Grand Cañon primordial fossils. However, Mr. Walcott has found in a bed situated at a third of the thickness of the formation in descending order, three fossils: one Discinoid shell, an obscure *Hyolites*, and pieces of a segment of what seemed to be a trilobite—with such paleontological fragment it is impossible to synchronize with certainty, those beds with the great formations of the Middle and Lower Taconic. Only we can say, that it is a first hint of the existence there of a fauna which may prove to belong to the infra-primordial fauna, and may be referred with doubt and provisionally only, to the Esthonian formation or *Schmidtia* zone. The strata containing that very small fauna of the Grand Cañon has been called "Chuar formation."

Nevada.—The Eureka district of Nevada, explored with some detail by Messrs. A. Hague and C. D. Walcott, presents a development of about 2,000 feet thick of strata belonging to the Lower and Middle Taconic. First, we have resting on the granite, the "Prospect Mountain quartzite," 1,500 feet thick, in which, until now, no fossils have been found. Being below the Georgia formation or *Elliptocephalus* (*Olenellus*) zone, as we shall see presently, those quartzites seem to represent the St. Albans group, or at least a part of it.

Directly above the quartzite there are one hundred feet of red shale, surmounted by five hundred feet of magnesian limestone. Until now the limestone has not furnished fossils; but the red shales are fossiliferous, and here is the list published by Mr. Walcott: *Olenellus* (*Elliptocephalus*) *gilberti* ([1]), *Ol. iddingsi*, *Olenoides quadriceps*, *Anomocare parvum*, *Ptychoparia*, *Scenella*, and *Kutorgina*. Farther up, in the magnesian limestone, in a band of shales, enclosed in the limestone, are the

following fossils: *Olenoides quadriceps*, *Ptychoparia*, *Agnostus* and *Scenella*. All these fossils are forms closely allied to species of the Georgia formation in New York, Vermont and Canada. So we have in Eureka the upper part of the Middle Taconic or *Elliptocephalus* zone corresponding and the homotaxis of the upper part of the *Paradoxides* zone or Bohemian formation of the Acadio-Russian areas.

In the Highland range, 125 miles south of Eureka, the Georgia formation is well developed, containing the following fossils: *Olenellus* (*Elliptocephalus*) *gilberti*, *Ol. iddingsi*, *Ptychoparia* and *Hyolites*.

East of the Highland range, at 20 miles distance, in the Ely mountains near Pioche city, is the *Elliptocephalus* (*Olenellus*) zone with fossils having a complete Georgian aspect and *facies*, such as: *Elliptocephalus* (*Olenellus*) *gilberti*, *Olenoides typicalis*, 2 *Crepicephalus*, *Hyolites*, *Orthis*, *Acrotreta*, *Acrothele*, *Kutorgina* and *Lingulella*. In regard to *Olenoides typicalis*, as professor F. Schmidt remarks in "Weitere Beiträge zur Kenntniss des *Olenellus Mickwitzi*," p. 4, St. Petersburgh, 1888, it is related to *Olenellus* (*Schmidtia*) *mickwitzi*, but differs greatly by the inferior part of the thorax below the telson; it differs also in the pygidium and the head. The *Olenoide*, *typicalis* may be considered as a degenerate form and the last representative of the group of the *Schmidtia*.

Farther south in Nevada, at the end of the Timpahute range, the Georgia fauna has been found by Mr. G. K. Gilbert, represented by the two *Elliptocephali*, *gilberti* and *iddingsi*.

Utah.—In the Wasatch mountains of Utah, at the Big Cottonwood cañon, above 11,000 feet of non-fossiliferous strata, the Georgia formation was found with its characteristic fauna: *Elliptocephalus* (*Olenellus*) *gilberti*. *Ptychoparia*, *Leperditia*, *Hyolites*, *Kutorgina* and *Lingulella*. As no fossil has been found yet, in the 11.750 feet of strata below the horizon of the *Elliptocephalus* zone, there are strong hopes that we may find in that section the equivalent and homotaxical horizon of the other groups of the Middle and Lower Taconic.

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(1) The resemblance with *Elliptocephalus* (*Olenellus*) *thompsoni* is such, that it is doubful, if it is a distinct species; it is, at all events, a very closely allied species and a representative of the Georgia species. As to a generic identification with *Holmia Kjerulfi*, it is impossible to accept it with such difference in the pygidium, in the thorax and in the head.

At Ophir city, in the Oquirrh range, Utah, the Georgia formation contains *Elliptocephalus* (*Olenellus*) *gilberti*, *Bathyuriscus* and *Lingulella*. And finally at Antelope Spring, in the House range, western Utah, Mr. Gilbert has recognized the Georgian fauna composed of *Agnostus*, *Olenoides*, 2 *Ptychoparia* and *Acrothele*.

British Columbia.—In the Rocky mountains of Canada, near the vicinity of the passes followed by the Canadian Pacific railroad, fifty-first parallel, the Taconic system is well developed and occupies a most important place in the stratigraphy of that region. Dr. Charles Rominger has first made known a primordial fauna, found at mount Stephens by an astronomer, Mr. O. Klotz. The fossils described by Dr. Rominger, are: *Oxygia klotzi*, *Ox. senata*, *Embolinus spinosa*, *Emb. rotunda*, *Monocephalus salteri?* *Conocephalites cordilleræ*, *Bathyurus?* *Agnostus*, *Hyolites*, *Orthis?* *Kutorgina*, *Metoptoma* and *Obolella*. ("Description of Primordial fossils from Mount Stephens, N. W. Territory of Canada," in *Proceed. Acad. Nat. Sc. Philadelphia*, 1887, pp. 12-19.)

Mr. R. G. McConnell has published in the "Annual Report of the Geological Survey of Canada for 1886," a description with an important section of the Castle Mountain group. He has found fossils at two different horizons; the lowest one indicates the *Elliptocephalus* (*Olenellus*) zone with an *Elliptocephalus* (*Olenellus?*), a *Ptychoparia*, and a *Protypus*. That small fauna rests on 10,000 feet of a series of dark colored argillites and sandstone, in which no fossils have been found yet; but which very likely may prove to represent the lower group of the Middle Taconic and Lower Taconic, just like the St. Albans group of Vermont and the lower great series of Cottonwood cañon in Utah, and the Grand Cañon of the Colorado.

Above the horizon of the *Olenellus?* (*Elliptocephalus*), at a distance estimated at 2,000 feet, Mr. McConnell has found the fauna described by Dr. Rominger, which seems to indicate for the Georgia formation of British Columbia a thickness four or five times greater than at the typical locality of Georgia, Vermont. But in such grouping of strata, in great dislocated masses of slate, it is impossible to give very exact measurements for the different formations; and we may regard the two horizons of fossils at mount Stephens, in the Castle Mountain

group, as belonging to the upper part of the Middle Taconic, and the homotaxical representative of the upper portion of the *Paradoxides* zone or Bohemian formation.

[TO BE CONTINUED.]

STUDIES ON MONTICULIPORA.

By Dr. C. Rominger, Ann Arbor.

This group of paleozoic fossils, very prolific in numbers and forms, familiar to every paleontologist in a general way, has nevertheless remained very imperfectly known until within a comparatively recent time, when the microscopic method of investigation began to be adopted by paleontologists. Among those who contributed to a more accurate knowledge of the Monticulipora tribe Prof. Alleyne Nicholson was one of the foremost. His first publication on this subject, making part of the geological reports of the State of Ohio, is based on examination of specimens, found in the Hudson River group in the environs of Cincinnati, conducted according to the old customary method, restricting itself to observation of surface characters, visible with the naked eye, or assisted by the use of an ordinary lens. Mr. Nicholson himself claims this part of his work to be merely a preliminary first attempt to arrange the numerous differentiated forms before him, within certain definite specific limits. In a second publication, entitled "*On the Structure of the Tabulate Corals,*" his results are derived to a great extent from the microscopical examination of thin sections, whereby a number of characters disclosed themselves to him which previously had escaped his notice, and which in many instances demanded more or less important changes of his formerly expressed views. The subsequent continuance of these microscopical observations, constantly adding new facts, involved for him the necessity of many other progressive modifications of his views, which are laid down in his last publication "*On the Structure and Affinities of the genus Monticulipora.*" Therefore passing review over his works, only the statements made in this last essay can be taken as the true exponents of his temporary standpoint, which, in his own opinion, is susceptible of great improvements by the prospective discovery of new facts by his followers in the same line of study.

About the same time that Mr. Nicolson's publications appeared Mr. E. O. Ulrich, of Cincinnati, took up the study of the monticuliporoid family as a specialty and made the results of his labors known through a succession of essays appearing in the Journal of the Cincinnati Society of Natural History. Later, in the fourteenth annual report of the Geological Survey of Minnesota, he gives descriptions of quite numerous representatives of this group, and just recently, his contributions to micropaleontology of the Cambro-silurian rocks, came out as a part of the geological reports of Canada. We are also promised by him an explicit treatise on Bryozoa in the eighth volume of the Geological Survey of Illinois, not yet printed. The different publications of Mr. Ulrich give creditable testimony of his zeal and his ability in making observations, but it is to be regretted to see him attribute to every trifling modification he observes in these structures an undue importance which induces him to propose on the strength of these, a fabulous number of generic and specific distinctions, which, instead of helping the reader to a quick and clear perception of the typical features of the very numerous representatives of this group, inundate his mind and memory with a flood of vague definitions which is bewildering and repulsive.

As I had always felt a particular interest in the study of this same group of fossils and had published, twenty-five years past, a small essay, entitled "On the Structure of Chætetes and Related Forms" in the proceedings of the Academy of Natural Sciences of Philadelphia (1866), I take the occasion now to communicate the results of continued studies in this direction, which filled out a good many of my leisure hours during later intervals, by passing a critical review over the works of the two mentioned writers, whereby opportunity offers itself to corroborate many of their observations, and on the other hand, points of disagreement in observations, or in conclusions based on such, can be most conveniently argued.

In the first chapter of his work on *Monticulipora* Mr. Nicholson explicitly discusses the general history of the genus *Monticulipora* and hereby gives expression to the views entertained by himself. A second chapter treats on the general and comparative structure of *Monticulipora*, which genus in its wider sense he defines as "Forms in which the corallum is composed of numerous closely approximated tubular corallites, the

walls of which are never absolutely amalgamated with one another. Walls imperforate; septa entirely wanting; tabulæ always present in greater or less number, though sometimes obsolete or nearly so; generally 'complete' and approximately horizontal; sometimes in a peculiarly modified manner 'incomplete." Corallites usually divisible into two distinct groups, one of large, the the other of small tubes; the latter being usually, but not always, more closely tabulated than the larger tubes, or showing other peculiarities of structure. Surface often, but not always, exhibiting at regular intervals definite areas which are occupied by corallites which are either larger or smaller than the average. These areas may be elevated above the general surface, when they are called *monticules*, or they may be level with the surface or slightly depressed below it, when they are called "*maculæ*." He then goes on to describe the form of the corallum, as being extremely variable, though often constant for the same species. He distinguishes a massive, a discoid, dendroid, laminar or frondescent and an encrusting mode of growth, whereby often, particularly in the dendroid forms, an obvious differentiation of the corallum into an axial and peripheral region exists In the axial region the corallites are generally thin walled and angular, often with few tabulæ. On the other hand, in the peripheral region the corallites are often thick walled, commonly rounded, and usually with many tabulæ; likewise the statement is made that interstitial tubular and the so-called spiniform corallites, if present, are most generally confined to this peripheral region. This differentiation into an axial and peripheral region is less developed in forms of massive or discoid mode of growth. Considering the structure of the tube walls of Monticulipora Mr. Nicholson points out the general duplicity of the walls of contiguous tubes, which in certain forms is permanently preserved, as for instance in *M. trentonensis*, *M. jamesi* and others. In other forms, such as *M. undulata, petropolitana*, etc., the walls are so thin and so intimately united that in sections they present themselves as delicate dark lines without structure. In a third group represented by *M. ramosa*, *M. o'nealli*, etc., Mr. Nicholson describes the substance of the dividing walls sufficiently thickened as to exhibit a dark ring in the circumference of the orifices, but the outer limits of the juncture of the adjoining

walls are merely indicated by an intermediate lurid space without a line of demarkation. Finally he mentions *M. andrewsii*, *M. gracilis*, *M. moniliformis* as examples which exhibit an amalgamation of the adjoining walls to such an extent that the substance intermediate between the visceral cavities appears as a homogeneous mass of high-colored sclerenchyma, barely showing in the neighborhood of the actual tube cavities some fine concentric lines of deposition. These enumerated modifications in the wall structure are to my conceptions not the exponents of a real difference in their organization, but merely specific variations of the same structural type.

The superimposed obliquely ascending layers of sclerenchyma, well represented in fig 3, page 40, of Mr. Nicholson's work, are, in my opinion, not a structural peculiarity, confined to the terminal part of the tube-walls, but the entire tubes, from base to top, are built of a succession of similarly superimposed oblique layers, which unite in an arch or under a more or less acute angle with similar layers of the adjoining tubes. No part of the wall is structureless, as Mr. Nicholson expresses it, but I admit that the mode of preservation and the delicacy of the tube-walls often obscures the traces of structure. The mentioned succession of obliquely superimposed sclerenchym layers not only builds up the outer walls of the tubes, but all the tabulæ intersecting the tube cavities are a direct continuation of such layers, periodically spread across the channel and constituting then a regular cup. It is the same process of growth that builds up the calyx of a cup coral with its transverse tabulæ, but I am far from suggesting a relationship; my inference is only to show how nature often uses the same means in the accomplishment of organic structures of altogether different affinities.

A very common superficial character of Monticulipora and allied forms is the occurrence of numerous nodular or spire-like projections, located in the circumference of the tube orifices and on the angles of junction between the tubes. Among the specimens described by Milne Edwards from the strata of Cincinnati, he observed in one of the kinds, numerous stout spinules disseminated over the surface and considered this to be a character of sufficient importance to distinguish that form from the associated Monticuliporas as a peculiar generic type, under the name "*Dekaya*," which dis-

tinction has always been accepted by Mr. Nicholson and by Mr. Ulrich.

In the previously mentioned essay published by me in 1866, I objected to the separation of this form, from *Monticulipora*, on the ground that an overwhelming majority of all the forms comprised under the name *Monticulipora*, is provided with similar spinulose prominences, and that in the structure of the so-called *Dekaya* no other peculiarity can be pointed out, in which it differs from *Monticulipora* proper. I suggested also, that these spinules were of subordinate functional value, as in the same specimens a portion of the surface may exhibit spinules, while in another none are observable.

Mr. Nicholson is inclined to attribute to these superficial prominences a greater physiological importance, by comparing them with the ordinary corallites, as being a peculiarly modified form of Zooide, which he designates by the name of "Spiniform Corallites," and describes as blunt, usually imperforate projections, in which he exceptionally could sometimes discover an apical aperture. From the appearance of these spines in thin sections, their composition of concentric laminæ of sclerenchyma, with a dark, or a clear lucid space in the center, leaves no doubt in him, that these structures are primitively hollow, and represent a peculiar modification of corallites,whose cavity becomes in progress of growth filled up with a secondary deposit of sclerenchyma.

I have examined several hundreds of sections of *Monticulipora* specimens provided with spinules, and admit the correctness of Mr. Nicholson's observations, that these structures resemble, in tangential as well as in longitudinal sections, tubules with very thick concentrically laminated walls, and that in some instances even an actual central canal seems to exist, usually, however, the center of these spinules is solid, originally so, and not as Mr. Nicholson thinks, by a secondary process of deposition, replenished with sclerenchyma.

The lucid central portion of the spinules, supposed to have been the former channel, is not defined from the surrounding laminated sclerenchyma mass, but merges into it by insensible gradation. If these spinules were actually tubules in structure and analagous to the ordinary tubules of the corallum, they should also be built up according to the same plan with the others, but this is not the case. The ordinary tubules are,

as has been incidentally described before, built up by a succession of delicate layers, directed from below, upward and outward. Periodically their cavity is intersected by transverse diaphragms, which likewise are an extension of such layers across the tube-channel, in which case the deposited layers form a closed cup, and the whole length of the tube may be considered a succession of similar cups, one invaginated into the other and open toward the periphery. The structure of the spinules, with regard to their supposed central cavity, is just inverted; their lamination, in perfect accordance with the lamination of the ordinary tubules, holds an ascending anticlinal position toward their central canal and forms a series of invaginated cups closed at the apex and not in the bottom, which excludes the possibility of a central channel, opening on the surface, like the other tubules. To my conception the spinules are an integrant part of the ordinary tube-walls, whose margins, by exuberance in secretion of shell matter, form nodular prominences in certain spots of their circumference, which, amalgamating with similar prominences of the adjoining tube-walls, contribute the spinules. On the line of junction between these joining walls, usually an uninterrupted continuation of the laminæ, from one side of these conical prominences to the other, can be observed, but sometimes on this line, by incomplete amalgamation of the ends of the anticlinal layers a central vacant space is left which resembles the channel of a tube, but the physiological functions of such merely occasionally developed tubular spaces,are not comparable with those of the ordinary tubes, which are the domicile of an organism secreting this calcareous structure, in layers conforming to the shape of its body. The channels, perforating exceptionally the center of the spinules, have no walls of their own; they are surrounded by the walls of neighboring tubes, whose structural channels hold an anticlinal position toward the cavities of the spinules, which structure is a positive proof that these channels cannot be a specific modification of tubular Zoœcia, or else they would be enclosed by independent walls, of the make of the inhabiting Zooidia, which walls would hold necessarily a synclinal and not an anticlinal position of their lamination toward the cavity, as the case is. The occurrence of spinules is generally restricted to the peripheral ends of the tubes, they form columnar, incrassated,

longitudinal streaks in the wall substance, within the extent of the peripheral area, (Wandstraenge, Dybowsky) of the different *Monticulipora* species, while in *Stenopora*, as a rule, this incrassation is subject to periodical interruptions, and appears in vertical sections through the branchlets, as a series of beads, stringed together, instead of presenting continuous columns as in *Monticulipora*.

It may be of interest if I remark on this occasion, that in none of Silurian, Devonian or lower Subcarboniferous monticuliporoids this beaded appearance occurred to me, but that specimens from the Chester group and from the different strata of the Coal Measures,all exhibit this beaded appearance, and besides have a large central perforation of their diaphragms, which, according to Nicholson, is another essential character of *Stenopora*. A third characteristic feature of *Stenopora* mentioned by Prof. Nicholson, a perforation of the tubes by connecting pore-channels, I have not been able to recognize in any single instance, although some of the examined specimens were so favorably preserved that if such perforations existed they could not have escaped my observation.

The previous expositions regarding the occurrence and structure of the spinules in *Monticulipora* are not very favorable for the sustenance of Mr. Nicholson's suggestions that these structures have a functional analogy with the ordinary tubes and deserve therefore to be designated as "spiniform corallites." I may be equally at fault, considering these organs as merely ornamental, because I know nothing definite about their vital functions; but the circumstance that in parts of one and the same specimen spinules are often abundantly developed, while in other parts of the surface they are entirely missing, or only thinly scattered, seems to me a satisfactory indication that their functional importance cannot be very great, and at all events not essential for the vital existence of such specimen.

In the same category with the ordinary superficial spinulose projections probably belong spinules, which I discovered recently on inner circumference of the tube-channels of *Monticulipora moniliformis* Nicholson. They are accurately similar to the spinules represented by Mr. Nicholson on page 69 of his work, in the tubes of *Heteropora neozelandica;* in tangen-

tial sections from four to seven of these can be seen encircling the lumen of the tubes, not all of them stand on the same level, nor in longitudinal rows, but they are scattered singly all over the inner cavity without apparent order. Similar spinules I found in great numbers covering the inner surface of the tubes of a *Monticulipora* or *Stenopora* from the Chester group of Arkansas. With reference to *Mont. moniliformis* I have to state yet the perfect independence of the inner horizontally projecting spinules, from the much larger ones, vertically projecting above the angles of junction between the tubes. The discovery of spinules covering the inner surface of the tube-channels in a few species of *Monticulipora* and their absence in the majority of other species, while it proves a wider distribution of this structural character than previously was known, the restriction of the appendages to a few species only, demonstrates at the same time, that their functional value cannot be very great, no more than a specific peculiarity, of the same order, as the more generally developed superficial spinules. Proceeding with the chapter on the comparative structure of *Monticulipora*, Mr. Nicholson describes the corallum of *Monticulipora* as being generally dimorphic, explaining, that he does not follow the current opinion regarding the minute tubules, interstitial between the larger ones, as young corallites, or as cœnenchymal tubuli, but referring to Mr. Moseley's researches on the living *Heliopora*, he feels himself thoroughly satisfied that in *Monticulipora* a similar dimorphism exists to that in *Heliopora*, and that the different sets of tubes in *Monticulipora* are inhabited by different sets of Zooids. He admits, however, that there are forms of Monticulipora resembling the dimorphic species, in which all of the corallites of the colony are apparently similar in their internal structure and approximately equal in size, of which he hesitates to assert positively their dimorphism.

Discussing the nature of the tabulæ, the form and arrangement of these structures in different corallites of the colony, Mr. Nicholson goes on to state that they are never wholly absent in any form of *Monticulipora*, but sometimes entirely wanting in portions of the corallum. That the tabulæ are in the majority of monticliporoids"complete"horizontal or curved, but that in other forms a peculiar incompleteness of the tabulæ occurs, whereby an excentric or sometimes subcentral

large perforation interrupts the continuity of the much curved obliquely downward-bent diaphragms, which in longitudinal sections appear like a string of imbricating vesicules adhering to the sides of the tubes and leave an open channel alongside of them, which usually is found intersected periodically by straight diaphragms extending from the vesicules to the opposite free portion of the side walls. Occasionally these incomplete tabulæ have also the shape of short-tubed funnels one invaginated into the other. The set of small tubules, usually developed in the forms with incomplete tabulæ, is in distinction from the large tubes always intersected by closely approximated and complete straight diaphragms. Concerning the occurrence of longitudinal septa within the tubules of *Monticulipora* Mr. Nicholson with propriety remarks that nothing of septa, in the proper sense of the term, has ever been detected. The indentation of the orifices frequently observable in certain spinulose forms of *Monticulipora* is caused by a merely accidental projection of spinules into the orifices, whose outer margins they occupy, and is not at all comparable with the radiation of septate corals. Also the spinules which I discovered in the tube-cavities of *Monticulipora moniliformis* Nicholson, and in another Carboniferous species not yet named, are no exception to this rule, as they have no analogy with radial septa.

In the third chapter of his book Mr. Nicholson gives first his opinion on Prof. Lindstroem's views, who thinks *Monticulipora* to be only a certain stage in the developement of a *Discoporella* or *Ceramopora*, passing first through a transitory *Fistulipora* stadium, and finally in its full developement representing a *Monticulipora*. This totally erroneous conception, is repudiated by Mr.Nicholson as in direct opposition with his own observations, and I fully concur in this repudiation not only because observations on American specimens prove a total independence of these 3 generic types, but also because specimens I received from Mr. Lindstroem, to demonstrate his assertions, after careful examination,exhibited an alternate incrustation of one form by the other, but no genetic connexion whatever.

In a second paragraph of the third chapter, *Monticulipora* is compared with the Mesozoic and yet living genus *Heteropora*. After consideration of many points of resemblance between the two, the perforated walls of *Heteropora* and the spinules pro-

jecting into their tube cavities appear to Mr. Nicholson differences of sufficient import to abrogate a real close affinity between the two genera. The occurrence of spinules within the tubes of certain species of *Monticulipora*, which is stated by me previously, invalidates one of the supposed principal characters of differentiation, but notwithstanding this, I concur in in Mr. Nicholson's opinion, believing, that the perforated structure of the inseparably united tube walls of *Heteropora* not differing in any way from the smaller interstitial tubules, is for itself alone, a difference, derogatory to a very close relationship between *Monticulipora* and *Heteropora*, but I still believe that *Monticulipora* stands in its general organization nearer the Bryozoa than the Alcyonaria, which latter are regarded by Mr. Nicholson as the group to which *Monticulipora* belongs.

In chapter IV, the relations of *Monticulipora* to *Chætetes*, *Stenopora*, *Tetradium Ceramopora* and *Heterodictya* are expounded in a mode, which in a general way meets my approbation. *Chætetes* is defined, as composed of inseparably united tubules of one kind only, which multiply by division, instead of lateral gemmation, as *Monticulipora* exhibits it; these forms first appear during the Carboniferous period. Another form, beginning at the same period, is *Stenopora* Lonsdale, redefined by Mr. Nicholson, as resembling a typical ramose *Monticulipora*, whose tubules in the peripheral area of the stems undergo a process of incrassation, with periodical interruptions, while in *Monticulipora* this process of thickness went on uniformly. This periodicity in the accretion gives the walls of *Stenopora* an annulated appearance like a string of beads. A further peculiarity of *Stenopora* is found in the structure of its diaphragms, which in part being complete and flat, exhibit in another portion a large sub-central perforation with a thickened slightly deflected rim round this opening. A third generic feature, ascribed by Mr. Nicholson to *Stenopora*, is very questionable in its reality; this is a perforation of the tube walls by communicating pores as in *Favosites*. In his statements he relies on specimens of *Stenopora jackii* from Australia in which he claims to have discovered the unmistakeable existence of such pores, while on the other hand he admits his failure to discover similar pores in other species of *Stenopora* which came under his observation. In a number of specimens found in the Chester group of the Mississippi valley and in the

Coal Measures above, I could plainly recognize the beaded structure of the tube walls and the centrally perforated diaphragms, typical for *Stenopora*, but in none of the numerous sections made of specimens of this kind I was able to observe the presence of connecting mural pores. I express therefore my earnest doubts whether any species of *Stenopora* is provided with such channels of communication.

In the further progress of comparisons the general resemblance of *Tetradium* to the massive forms of *Monticulipora* is mentioned, but considering the structure of the first, of inseparably united tubules of one kind only, which exhibit from 3 to 4 inflexions of their walls, which project into the cavity as prominent longitudinal septa, besides a different character in the transverse tabulation, Mr. Nicholson comes to the appropriate conclusion, that there exists no closer relationship between the two genera.

Comparing *Ceramopora* with *Monticulipora* he recognizes a much closer affinity, but considers the generally oblique position of the tube orifices to the surface in *Ceramopora* and the projecting rim surrounding them, besides a difference in the nature of the interstitial cell spaces of the compared forms, as peculiarities of sufficient import to separate them as generically distinct.

A fifth chapter is devoted to an attempt of subdivision of *Monticulipora* in its wider sense, into subordinate groups, and from a standpoint of practical expediency he distinguishes from *Monticulipora* in a more restricted sense, the genera *Fistulipora* and *Constellaria*, and *Dekaya*, although he admits a very close relationship between them and *Monticulipora* proper. He then correctly points out the differences between *Fistulipora* and *Monticulipora*, but I believe commits an error in identifying *Fistulipora* with *Callopora* of Hall, the type form of which is *Callopora elegantula*. The interstitial cells of this latter form have always the shape of cloudy tabulated conical tubules, intercalated between the peripheral portions of the larger tubes and not developed in the central portions of the stems, and the orifices of the larger tubes, opening rectangular to the surface never project with free rims above the general surface. In *Fistulipora* the orifices of the larger tubes always open more or less oblique to the surface and project with an annular, or one-sided labial rim, over the general surface. Its interstitial cell-

spaces are much more numerous and take part in the constitution of the corallum throughout its entire mass; moreover these interstitial cells never have the form of gradually enlarging conical, closely tabulated tubules, but are arranged in superimposed vesicular layers with laterally interlocking vesicules incompatible with the presence of a common wall inclosing the superimposed cellspaces of very unequal dimensions.

Mr. Nicholson aware of this fact, draws a comparison between *Heliolites* and *Propora* which differ among themselves in a similar manner, one having an obviously tubular interstitial tissue, the other presenting like *Fistulipora*, layers of interlocking vesicules As this comparison implicitly admits an equal difference between *Fistulipora* and *Callopora*, as we observe it in *Heliolites* and *Propora*, it follows that Mr. Nicholson acknowledges to *Callopora* the same typical independence as exists between *Heliolites* and *Propora*, *Sycllia*. On this occasion I feel induced to remark that the above comparison strikingly illustrates how nature repeated its structural designs in widely different organisms in almost exactly the same manner. *Constellaria* Dana, is by Mr. Nicholson considered as synonym with *Stellipor a*Hall. Mr. Ulrich thinks the two differ essentially. As I have never seen an authentic specimen of *Stellipora*, I can give no definite opinion, but it appears to me, that an identification of the Hudson River group fossil with the form described by Hall as *Stellipora antheloidea* is not justified by the figures given by Hall, and also his description of the unique specimen, does not apply to *Constellaria* of the Hudson River group.

In the above mentioned essay, published by me in 1866, I had from the external appearance of *Constellaria*, which in many respects resembles *Fistulipora*,inferred their generic identy, and also Mr. Nicholson considers them so closely related that he is in doubt whether a generic separation of the two is advisable. Examination of thin sections, however, has since fully convinced me, that except this external similarity, there is little resemblance in the structure of *Constellaria* and *Fistulipora*. In the latter, the interstitial vesicules are equally developed through the entire corallum and form an interlocking continuous plasma, into which the larger tubules are immersed. In *Constellaria* the interstitial cells are confined to the peripheral crusts of the stems, whose interior is exclusively formed

of the larger kind of tubules, and the peripheral interstitial cells are not an indiscriminate mass of interlocking vesicules, but evidently are transversely tabulated conical tubules, corresponding with those, peculiar to the species of *Monticulipora*, which Mr. Nicholson assembled under the name *Heterotrypa.*

The genus *Dekaya* of Ed. & Haime has been accepted by Mr. Nicholson with the remark that its distinction from spiniferous species of *Monticulipora* is merely an arbitrary one by which the species can be conveniently distinguished as a group apart, but in reality such distinction is an endless source of confusion. The great majority of all Monticuliporas are provided with spinules and a distinction of forms with large and more distant spinules from those with smaller ones is as vague as the difference between large and small, without having a defined standard of magnitude for comparison. On the other hand are those spinulose prominences in none of the forms, provided with them, equally developed; some portions of a stem may be conspicuously ornamented with them while another part of of it does not exhibit any. I reject, therefore, the acceptance of *Dekaya* as being an obnoxious ballast to the science.

Monticulipora, in its restrictive sense, is defined by Mr Nicholson as: "Coralla composed of tubular corallites which are mostly of two kinds, differing from one another in relative size and also in their tabulation. The small corallites are never so greatly developed as to entirely isolate the larger tubes except in an occasional corallite, nor do they form star-shaped elevated monticules. The tabulæ of the small corallites never become vesiculose, nor are even their walls obliterated. Spiniform corallites commonly present and may project above the surface as blunt spines, but they do not form conspicuous surface columns."

The genus as above defined includes a large number of forms exhibiting great variations in internal structure. Mr. Nicholson therefore provisionally proposes a sub-division of the so-framed genus in a number of subgenera. These are:

"*1, Heterotrypa; 2, Diplotrypa; 3, Monotrypa; 4, Prasopora; 5, Peronopora.*"

Heterotrypa includes conspicuously dimorphic forms with two sets of corallites of different sizes. The larger ones of sub-polygonal or sometimes rounded shape are more or less thick-

transformation into normal larger tubes. In species like *H. moniliformis* a dimorphism can scarcely be claimed, as only a very limited number of smaller interstitial tubules occur, which do not differ in structure from the larger ones and by right can be considered as young ordinary tubes.

The *subgenus Diplotrypa* is intended to embrace specimens of hemispherical growth, with obviously distinct sets of larger and smaller tubules, which latter are much more septate than the larger ones and are uniformly developed throughout the corallum from its basal commencement to the upper surface. There is also no thickening of the tube walls observable as they approach the periphery, but this is not a typical peculiarity for *Diplotrypa*, but in all other forms of *Monticulipora*, which grow in globular or hemispherical masses, the tubes do not appreciably thicken towards their peripheral ends. On the contrary all Monticuliporas of ramose growth become much more thick-walled near the surface than they are in the central parts of the stems.

The subgenus *Prasopora* perfectly corresponds with *Diplotrypa* in mode of growth, the only difference between the two is, the development of incomplete vesiculose diaphragms aside of ordinary complete tabulæ in *Prasapora*, while in *Diplotrypa* only complete transverse tabulæ occur and no vesicular ones. As in many instances the developement of vesicular incomplete diaphragms occassionally occurs, where as a rule only complete ones are observed, and as inversely specimens of typical *Prasopora* exhibit not rarely a part of their larger tubes intersected by complete transverse tabulæ only, with almost total exclusion of the incomplete vesicular kind, in such case the structure of the corallum is absolutely identical with that of *Diplotrypa*, and as the development of vesicular diaphragms is an invariably constant structural feature of *Prasopora* in all the specimens or portions of specimens, I am of the opinion it would be better to suppress *Diplotrypa* altogether and subordinate the forms concerned to *Prasopora*, allowing in its definition the exceptional want of development of incomplete vesicular diaphragms. The only difference is, that the tubes in *Prasopora* are not perceptibly incrassating as they approach the periphery, while in *Peronopora* the tubes are subject to a considerable thickening process in the pheripheral parts of the coralla. Mr. Nicholson states

also that the mode of growth in *Peronopora* is either laminar or incrusting, but there is besides a number of species of truly ramose growth, which harmonize in general structure with *Peronopora*. Among these I mention the forms which Mr. Ulrich has described under the name of *Homotrypa*, and which do not seem to have come under the observation of Mr. Nicholson. It has been remarked on a previous occasion that in all species of *Monticulipora* growing in hemispherical or subglobular form whatever other specified peculiarities they may have, the tubes are not subject to an incrassation as they approach the surface and on the other side, that invariably, with the ramose growth, a thickening of the tube walls near the surface is coincident; considered from this standpoint the whole difference between *Prasopora* and *Peronopora* rests on a difference in the mode of growth.

The fifth subgenus *Monotrypa*, comprises the forms whose tubules show no dimorphism,but are all of one kind. Some of these, located on or around the monticules, or in corresponding not elevate spots, are of somewhat larger size than the remainder, but they otherwise do not differ in structure from the smaller ones. Usually a few small angular cell openings are observable between the orifices of the ordinary tubes, but in sections it becomes evident that also these are only young tubules orignating by lateral gemmation from the older ones.

Certain species as for instance *M. moniliformis* are by Mr. Nicholson arranged under the genus *Heterotrypa*, but according to their structure their appropriate place is with *Monotrypa*.

These subdivisions of *Monticulipora*, considered as an expediency for general orientation, concerning the developement of certain structural characters, peculiar to a group of certain species and not, or not so well, developed in others, I find appropriate, but the division lines drawn by Mr. Nicholson between these groups,are no more than an artificial arrangement, placing the principal weight on a certain structural character in one instance, and in another on some other character, whereby frequently forms otherwise not closely related on account of the conspicuity of this one character, are assembled into one group, and on the other hand, closely related forms differing only in that one special point, are for such reason severed and disposed of in different groups.

As it regards the establishment of the precise limits of cer-

tain species described by Mr. Nicholson I find not rarely that the material under his observation must have been insufficient or that his observations lacked in accuracy. Mr. Ulrich decidedly is the more accurate observer of the two, although his vivid phantasy sometimes makes him believe he sees things which do not exist (for example the pores connecting the tubes of his *Homotrypa*), but comparing the work of the two writers, Mr. Nicholson's method of doing his work is far preferable to Mr. Ulrich's. The first strives to give his scientific communications in the shortest possible condensation, the second comes out with pompous display as a radical reformer. On the one side he parades on every possible occasion with the Darwinian evolution theory, speaks of the ancestry and derivation of certain forms, of prophetic types, and of analogies quite dubious in reality, still in total contradiction with the evolution theory. He tries to potentiate the most trifling differences in the structure of the examined fossils to a magnitude which is incompatible with specific or generic identity; and then, of course, such widely differing typeforms must have names, specific or generic, with Mr. Ulrich's signature behind them. Funny enough, Mr. Ulrich sometimes seems to feel himself embarrassed about the too prolific crop of his genera, for instance on page 247 while defining the genus *Atactoporella* he says, "*the new genus differs from Atactopora, in having numerous closely tabulated interstitial cells, cystoid diaphragms in the proper zooecia and thin instead of thick walls.*" Now comes the self-consoling phrase, "*These are all good generic characters,*" etc., which expression in my mind raises the suspicion that Mr. Ulrich was not so very sure whether the three mentioned characters really deserved such valuation.

To enter into a special critical review of the proposed systematical schemes of Mr. Ulrich would be a tedious task, and extend the bulk of this essay far beyond its intended limits. Many of these eccentricities will soon fall into oblivion without contradiction, but in justification of this summary disposal of the matter, a reproduction of the list of generic names applied by Mr. Ulrich to the several members of the group of fossils formerly and at present considered to constitute the single genus *Monticulipora*, will for a good many persons be a satisfactory excuse.

1. *Monticulipora* is for Ulrich represented in *M. mammulata*

D'Orby, which in Mr. Nicholson is a *Peronopora*, and by nine other species of his own make, four of which are not yet described.

2. *Heterotrypa* Nichols. is acknowledged, but of the seventeen species Nicholson places under this group, but two are in Mr. Ulrich's opinion, representing the genus; among these, however, he adds to the two, several other species described by himself.

3. *Diplotrypa* Nicholson is taken as valid.

4. *Monotrypa* Nicholson likewise, but only *Monotrypa undulata* is a true representation. *M. quadrata* and some other forms described by himself are

5. *Monotrypella* Ulrich.

6. *Prasopora* Nicholson is enriched by a number of new species of Mr. Ulrich's.

7. *Peronopora* Nicholson likewise receives a number of new representatives.

8. *Homotrypa* Ulrich are specimens of ramose growth very similar in structure to *Peronopora*.

9. *Homotrypella* Ulrich differs from No. 8 by more abundant interstitial cells.

10. *Stenopora* Lonsdale redefined by Nicholson is accepted.

11. *Callopora* Hall according to Ulrich embraces also the forms like *M rugosa*, *M. ramosa*, *M. dalei* M. Edw. *M. andrewsii* Nichols., *M. o'nealli* Nicholson, which association also in my own opinion is supported by a very close similarity in the structure of these forms.

12. *Calloporella* Ulr. grows in thin expansion in distinction from the ramose form of *Callopora*.

13. *Amplexopora* Ulrich is designed for several species described by Ulrich, but embraces also Nicholson's species *Hetcrop. moniliformis*, *barrandii*, *M. discoidea* Nich. and others.

14. *Batostoma* Ulrich is represented by *Hetcrotr. jamesii* Nich. and by *H. implicata* besides various of Mr. Ulrich's own species.

15. *Batosomella* represented by *Heterotr. gracilis* Nicholson besides several new species of Mr. Ulrich. On comparison with the description of Batostoma with the one given of itself, only differs from the former by the remark "Cell apertures small."

16. *Leioclema* Ulrich, enumerated by him among the monticuliporoids, is the form described by Hall under the name

Callopora punctata. In my opinion it does not belong in this association and represents an independent type.

17. *Atactopora* Ulrich, incrusting forms with abundant spinules giving the orificies by projection on their margin an irregular indented form.

18. *Atactoporella* similar to the former, but differing by numerous interstitial cells and by vesicular diaphragms which are said to be simply straight in the former.

19. *Dekaya* Edw. & H. is accepted.

20. *Dekayella* Ulrich are similarly spinulose forms with numerous interstitial cells.

21. *Nebulipora* M'Coy is accepted.

22. *Aspidopora* Ulrich are small convexo-concave expansions covered by an epitheca on the lower side, structure corresponding with other forms of *Monticulipora* of dimorphous character with abundant interstitial cells and spinules on the angles of junction of the tubes.

23. *Discotrypa* Ulrich of similar growth to the former, but destitute of spinules and interstitial cells.

24. *Petigopora* Ulrich. *Chætetes petechialis* Nicholson. Small parasitic cumuli of *Monticulipora* structure without interstitial cells but numerous stout spinules projecting from the angles of junction.

25. *Leptotrypa* Ulrich incrusting forms with thin walled polygonal tubes without interstitial tubes but provided with spinules situated on the angles of junction. Besides several newly described species. Mr. Ulrich places here also *Chæt. discoideus* James, *Mont. calceola* Miller and *Mont. clavacoidea* James.

26. *Spatiopora* Ulrich, thin incrusting expansions of the Monticulipora type with short shallow tubules, and some few interstitial ones, smooth or strongly tuberculated surface, and ornamented with spinules of considerable size.

Endeavoring to impress my mind with the distinguishing features of the long series of the just enumerated genera, I fancied to see each of them displayed in a circle, Mr. Ulrich's descriptions figuring as just so many spokes in a wheel, as the number of genera amounts to. I then supposed to make comparison of these generic spokes as they pass before my eyes, by setting this wheel in revolving motion, but alas! in the eagerness of my attempt I allowed the revolving motion to be-

come too rapid, the single spokes soon were no more discernible, I could see a quivering disk only, and everything around me began to rotate, then a prostrating giddiness overcame me, cold drops of sweat ran down over my temples, and in this dreadful agony, near to fainting, I fortunately could recollect an old popular German remedy, very efficacious in similar cases of ailings; it is, "the invocation of Sanctus Ulricus," accidentally a namesake of the author; I did so, and it was not in vain, I felt instantaneous relief after the invocation, but vowed, never to attempt a similar experiment, even on the risk of being deprived forever of the pleasure of fully comprehending Mr. Ulrich's interpretations of creation. Trusting in Mr. Ulrich's pronounced taste for eccentricities, I have committed one myself hoping some success from a humorous attack on his method of making natural history. I should be very sorry if he took it as meaning personal offense, I have wished only to open his eyes, to see, how little good he can do by wasting his ingenuity the way he does, and how much more he would benefit science and himself if he contented himself to communicate the results of his assiduous labors in the simplest possible manner, and with a perspicuity allowing to see every detail; but before all sketching with conspicuous outlines the structural characters, proving a harmonious unity of design in the organization of all these natural objects to which the present discussion has reference.

REVIEW OF RECENT GEOLOGICAL LITERATURE,

The Cretaceous and Teritary Geology of the Sergipe-Alagoas Basin of Brazil. By JOHN C. BRANNER. (Trans. Amer. Phil. Soc. Philada; vol. xvi, part 3, 1890; p. 369-434.) This study of Cretaceous and Teritary geology of a portion of Brazil forms an important addition to geological literature. Prof. Branner examined this region in 1875-1876 and according to his statements, the publication of the results was deferred in order that the Brazilian Government might publish the results, which however was never done, and Prof. Branner prepared a paper, which was read before the Philosophical Society, Sept. 7th, 1888. The author is very much impressed with the geological importance of this region and the results brought out later tend to prove this assertion. Their importance consists in the great range of deposits, the very rich fossiliferous beds and the "accessibility of good exposures across the entire section."

A section from the Archæan region north of Serra, through the Sergipe-Alagoas Basin to Sto. Amaro (on the sea) shows Archæan (?) schists conglomorates, sand-stones and shales, partially metamorphosed, limestones, shales sand-stones, oölitic limestones and sandstones, chalky beds, horizontal Teritary sandstones and clays and Quàternary and recent beds. The fossils of the Creatceous series appear to be unusually abundant. "The Stratigraphical Relations of and the conditions attending the deposition of, the Mesozoic beds" are then treated. The beautiful oölitic limstones of the Rio Sergipe will, according to Prof. Branner, no doubt be extensively utilized in the near future for architectural purposes. Part ii. "The Brazilian Mesozoic Basins other than that of Segipe-Alagoas." In this part are described the Cretaceous beds of Sao Francisco do Sul, Bahia basin and Pernambuco, and the part is concluded with "Correlation of the Mesozoic of the coast and the interior." Part iii. The Teritary Geology. Two noteworthy features of this Tertiary are the uniformity in the general character of the beds and the almost entire absence of fossils. Two hypotheses are offered for the latter: That these rocks were deposited so rapidly and with water so overloaded with sediments, that animal life was impossible, or that these beds once held organic remains, but that they have been dissolved out by infiltrating waters. Part iv, is a bibliograpy of some sixty-five titles. From the paper now before us it is evident that this region presents unusual advantages for a study, both geological and palæontological and it is to be regretted that the author of the paper has been unable to continue his investigations, so auspiciously begun.

Gems and Precious Stones. By GEORGE FREDERICK KUNZ. Pp. 336. Scientific Publishing Co., New York, 1890. Undoubtedly the most artistic book of the year and of a nature both popular and scientific is Mr. Kunz's present work. No one is better fitted to write upon this important subject than Mr. Kunz. His great experience with gems and precious stones in all conditions makes this present volume of inestimable value. The subject is treated in a manner which appeals both to the scientific and the general reader and in every line he finds himself delighted. Naturally enough the diamond is first treated and then all the other minerals which have been or could be used for gems are successively described. The author deserves great credit for the manner in which the book appears and the beautifully executed plates by Messrs. Prang & Co. add much to the value of this sumptuous volume.

Descriptions of New Species of Fossils. By GEORGE B. SIMPSON. (Trans. Amer. Phil. Soc. Phila.) Vol. xvi., part 3, 1890, pp. 435-460. The fossils described in this paper are contained in the collection of the Geological Survey of Pennsylvania. The species are all new and many are quite interesting; from the Chemung one new species of Orthis, Cyrtina, Meristella, Aviculopecten, Lyriopecten, Ptychorteria, Modiomorpha, Goniophora, Nucula, Syringothyris (this being

particularly interesting,) two Leptodesma, and six Platyceras; from the Clinton one new Orthis, Rhynchonella, Modiolopsis, Nucula, and two Tellinomya; from the Lower Helderberg one Chonetes, Acervularia and Cladopora; Waverly, one Syringothyris and two Rhynchonella; Homalonotus trentonensis Simp. n. sp. from the strata of the Trenton group near Reedsville, Mifflin Co., Pa.

Catalogue of Minerals for sale by George L. English & Co., Philadelphia and New York 15th edition, 1890, pp. 100.

This is undoubtedly the most comprehensive catalogue of minerals so far issued in this country, the work not only containing the trade catalogue but also a large amount of much useful information concerning many new minerals lately described, forty pages being devoted to descriptions of beryllonite, jarosite, lettsomite, phenacite, bertrandite, sperrylite, etc., all indicating the valuable character of the material this firm offers to the public.

In the price list Danna's classification is used, beginning with the native elements, sulphides, etc. Then follows an alphabetical list of new species and varieties (brought up to date of publication) which is undoubtedly one of the most valuable features of the book, which is then concluded with an index of all the species.

Messrs. English & Co. deserve great credit for this beautiful publication. It is well and neatly illustrated and very handsomely bound.

First Annual Report of the Geological Survey of Texas, 1889. E. T. DUMBLE, State Geologist, Austin: Royal octavo, xc. and 410 pp., with maps.

This fine volume embraces a general report by Mr. Dumble on the organization of the survey and on the preliminary classification of the Texas formations, and several accompanying papers, viz: By R. A. F. Penrose Jr. on the gulf Tertiary of Texas, by Robt. T. Hill on the Cretaceous rocks of Texas and their economic uses, by W. F. Cummins on the southern border of the central coal field, and on the Permian of Texas and its overlying beds, by Ralph S. Tarr on the coal fields of the Colorado river, by Streeruwitz on the geology of Trans-Pecos Texas, and by Theo. B. Comstock on the central mineral region of Texas.

The report of Mr. Comstock shows that in the Archæan in Texas, there are probably three series or systems of rocks, and in this respect, as well as in many of the details, the features of the Texas Archæan are strikingly like those of the Archæan of Manitoba and Minnesota.

Hamlinite; a new mineral. By Messrs. HIDDEN and PENFIELD. (Am. Jr. Sci. 39, p. 511.)

Five years ago the authors observed a new rhombohedral mineral occurring with *herderite* at Stoneham, Me. As the material then noticed was insufficient for chemical investigation the authors deferred publishing any results with the hope that more might be discovered; this hope has not been realized and the present paper is therefore apparently a preliminary one.

Hamlinite (after Dr. A. C. Hamlin, of Bangor, Me.) crystallizes in the hexagonal-rhombohedral system, the observed crystals measuring about 2 mm. Hardness 4.5, Sp. Gr. 3.228 in barium-mercuric iodide solution. Fusibility 4. Colorless to yellow. Qualitatively gives reations for phosphoric acid, water, fluorine, alumina, and the authors have come to the conclusion that the mineral is a new phosphate of beryllium and alumina with fluorine.

A preliminary annotated check-list of the Cretaceous invertebrate fossils of Texas. ROBERT T. HILL. (Bulletin No. 4, Geol. Sur. of Texas.) Austin, 1889.

This valuable publioation reveals the great labor that has recently been bestowed by Prof. Hill, on the Cretaceous of Texas, by which he has been enabled to more than double the recognized thickness of the Cretaceous, and to lay down, in a preliminary way, the paleontological data by which all its parts may be identified. Not to mention the early and fragmentary observations of Ræmer, Marcou, the Shumard brothers, and the paleontological determinations of Morton, by which some unproved generalizations were indicated, some of which are still in doubt, Prof. Hill has made the first systematic and continued research in the strata of that age in Texas. He demonstrated the existence of the great unconformable *Comanche series*, and although this series is claimed as *Neocomian* by Mr. Marcou, and the lowest part of it as Jurassic, there is no question of its actuality and of the credit that is due to Prof. Hill in elucidating its structure and its relations. Minor details will have to be worked out in the future, and as they cast their light on the disputed questions all the differences will be likely to disappear. For the field-geologist in the Texas Cretaceous, indeed for every laboratory worker, this check-list will serve as a guide and reference of great value. The list proves evidently that all the Cretaceous strata in Texas are more recent than the English Gault, although some have identified Texas fossils with those that in Europe belong to the Gault or the Neocomian.

RECENT PUBLICATIONS.

1. *State and Government Reports.*

First annual report of the geological survey of Texas, 1889. E. T. Dumble, F. G. S. A., state geologist, 410 pages with maps.

Geological survey of New Jersey. Annual report of the state geologist for the year 1889. 112 pages.

Bulletin of the U. S. Geological Survey, No. 54. On the thermo-electric measurement of high temperatures, Carl Barus. 313 pages with plates.

Bulletin of the U. S. Geological Survey, No. 55. Report of work

done in the division of chemistry and physics, mainly during the fiscal year 1886-87. 72 pages with plates. F. W. Clarke.

Bulletin of the U. S. Geological Survey, No. 56. Fossil wood and lignite of the Potomac formation, 96 pages. F. H. Knowlton.

Bulletin of the U. S. Geological Survey, No. 57. A geological reconnaissance in southwestern Kansas. 49 pages. Robert Hay.

2. *Proceedings of Scientific Societies.*

Transactions Kansas Academy of Science, vol. XII, part 1, 1889, contains proceedings of twenty-second annual session ;Notes on the occurrence of gold in Montana, J. R. Mead: On magnetic declination in Kansas, F. O. Marvin; Artesian wells in Kansas, and the causes of their flow, Robert Hay, F. G. S. A.; Some Kansas mineral waters, E. H. S. Bailey; Barite and associated minerals in the concretionary rocks of eastern Kansas, E. H. S. Bailey and E. E. Slosson, (abstract).

The proceedings of the academy of Natural Sciences of Philadelphia, Jan.-March,1890, contain: Pea-like phosphorite from Polk Co..Florida, Edward Goldsmith; Distribution of color marks in the Pteropodidae, Harrison Allen, M. D.; Fossil vertebrates from Florida, Jos. Leidy, M. D.; Notes on the genesis and horizons of serpentines of southwestern Pennsylvania, Theodore D. Rand; Geology of artesian wells at Atlantic City, N. J., Lewis Woolman.

3. *Papers in Scientific Journals.*

Am. Jour. Sci., July No. Southern extension of the Appomattox formation, W. J. McGee; Notes on the minerals occurring near Port Henry, N. Y., J. F. Kemp; Occurrence of Goniolina in the Comanche series of the Texas Cretaceous, R. T. Hill; Development of the shell in the genus Tornoceras Hyatt, C. E. Beecher; Fayalite in the Obsidian of Lipari, J. P. Iddings and S. L. Penfield; Selenium and Tellurium minerals from Honduras, E. S. Dana and H. L. Wells; Connellite from Cornwall, England, S. L. Penfield.

Am. Naturalist, Nov. No. Character and distribution of the genera of brachiopoda, Chas. W. Rolfe. *April No.* On the brecciated character of the St. Louis limestone, C. H. Gordon. *June No.* The persistence of plant and animal life under changing conditions of environment, Persifor Frazer.

Ottawa Naturalist, May No. On some of the larger unexplored regions of Canada, G. M. Dawson.

Can. Record of Sci., vol. IV, No. 2. Note of a fossil fish and marine worms in the Pleistocene nodules of Green's creek on the Ottawa, J. W. Dawson; Notes on göthite, serpentine, garnet and other Canadian minerals, B. J. Harrington; Scolecite from a Canadian locality, J. T. McDonald; On Asbestus, &c., J. T. Mc Donald; Lower Helderberg formation of St. Helen's island, Wm. Deeks.

4. *Excerpts and individual publications.*

The dynamic influences of evolution, Wm. H. Dall. [Read before the Biological Society of Washington, Mar. 8th, 1890.)

The Nampa Image. Correspondence relating to its discovery with explanatory comments etc. (From the proceedings of Boston Soc. Nat. Hist. vol XXIV, 1889.)

Channel Islands, by Dr. Lorenzo G. Yates, F.G.S.A. Stray notes on the geology of the Channel Islands. The mollusca of the Channel Islands of California. Insular floras. (Written for the ninth annual report of the state mineralogist of California,)

Description of some new genera and species of Echinodermata, from the Coal Measures and sub-Carboniferous rocks of Indiana, Missouri and Iowa; by S. A. Miller and Wm. F. E. Gurley.

The rivers of northern New Jersey, with notes on the classification of rivers in general, by William Morris Davis, delivered before the "National Geographic Society" at Washington Jan. 24, 1890. Published in the "National Geographic Magazine," Vol. II, No. 2.

The geographic development of northern New Jersey, by William Morris Davis and J. Walter Wood, Jr., (from proceedings Boston Soc. Nat. Hist. Vol. XXIV, 1889).

On some of the larger unexplored regions of Canada, by G. M. Dawson, D. S., F. G. S. extracted from the Ottawa Naturalist, May 1890.

On Cambrian organisms in Acadia, by G. F. Matthew, M.A., Trans. Roy. Soc. Canada. (Read May 30, 1889.)

The Iroquois Beach, a chapter in the geological history of lake Ontario, by Prof. J.W. Spencer, M. A., Ph. D., F. G. S.,Trans. Roy. Soc. Canada, (Communicated by Dr. T. Sterry Hunt, May 5, 1889).

Notes on the geography and geology of the Big Bend of the Columbia, by A. P. Colemn, Trans. Roy. Soc. Canada. (Communicated by Dr G. M. Dawson, May 15, 1889.)

5. *Foreign Publications.*

Die tertiären Bildungen des Kreidberges bei Lünenburg. Von M. Stümcke. Jahr. d. nat. wissen. Ver. f. d. Fürstentum Lünenburg, XI, 1888-1889, S. 91.

Mittheilungen aus d. Min. Inst. Keil, Bd. 1, Heft 2, contains: Bemerkungen über die Gneisse im Granulit des sächsischen Mittelgebirges, E. Danzig; Ueber den Wiesenkalk des Farbeberges bei Nindorf Betrachtungen über die Art und Weise, wie die Geschiebemergel Norddeutschlands zur Ablangerung gelangt sind. H. J. Haas; Ueber ein Neocomgeschiebe aus dem Diluvium Schleswig-Holsteins. E. Stolley.

Die Conchylien des Lösses am Bruderholz bei Basel. F. v. Sandberger. (Verhl. Nat. Gesell. Basel, 8 Theil. 3tes. Heft).

Ryoliten vid sjön Mien. af N. O. Holtz. (Sver. Geol. Undersok. Ser, C. No. 110).

Grenze zwischen ketten und Tafel-jura. F. Mühlberg. (Eclogæ geologicæ Helvetiæ. 1889, No. 5.)

On the origin of the basins of the great lakes of America. J. W. Spencer. (Geol. Soc. of London, April 16, 1890, Abstracts and discussion).

Annual report of the Department of Mines, New South Wales, for 1888. Folio, 233 pp., many maps and plates, Sydney, 1889.

Geological features and mineral resources, Maukai district, Queensland. R. L. Jack.

Geological observations at the heads of the Isaacs, the Suttor and the Bowen rivers, Queensland. R. L. Jacks.

Report on the Sellheim silver mines and surrounding district, Queenland. R. L. Jacks.

Kleine Mitth. aus min. Inst. Univ. Giessen, No. 6, contains: Neue Funde von Mineralien, Gesteinen and Versteinerungen aus der Umgegend von Giessen, A. Streng; Bemerkungen über den Melanophlogit, A. Streng; Eine neue Limatula aus dem oligocän des Mainzer Beckens, G. Greim; Ueber eine eigenthumliche Säulenbildung im Tageban des Braunsteinbergwerks in der Lindner Mark bei Giessen, J. Uhl; Ueber Regentropfenspuren ebendaselbst, J. Uhl.

Zeitschrift der Gesellschaft für Erdkunde zu Berlin, erstes heft, no. 145, "Der Isthmos von Korinth," eine geologisch-geographische Monographie, von Dr. Alfred Philippson.

Annales de la Societe Geologique de Belgique, tome seizième, 1888-1889, contains: Etude sur les dépôts gypseux et gypso-salifériens, M. Ch. De La Vallée Poussin. Etude geologique des Gisements de Phosphate de Chaux du Cambrésis, X. Stanier; Sur les affinités des genres Favosites, Emmonsia, Pleurodictyum et Michelinia à l'occasion de la description d' une forme nouvelle de Favositide du calcaire carbonifere supérieur, Julien Fraipont; Etude sur la stratigraphie souterraine de la partie nord-ouest de la province de Liege, Renier Malherbe; Note sur les roches cristallines recueillies dans les dépôts de transport, situés dans la partie méridionale du limbourg hollandais, Alph. Erens.

Földtani Közlöny, Jan.—Mar. 1890. (Geologische Mittheilungen.) Zeitschrift derUngarischen geologischen Gesellschaft. Redigirt von Dr. Moriz Staub. Budapest. Enthaltend Daten zur Geologie des Bakony (m 2 Abb.) Dr. F. Schafarzik; Beiträge zur geologischen Beschaffenheit der Umgebung von Munkács (m. 1 Abb.), Dr. J. Szádeczky; Beiträge zur fossilen Flora der Umgebung von Munkács (m. 1 Taf.) M. Staub; Ueber das geologische Profil des Scherunitzer Kaiser—Francisci Erbstollens (m. 1 Taf.); Zur Geologie des Djebel-Bu-Kornein in Tunis (m 2 Abb.), J. Jankó jun.; Kurze Uebersicht der in der Zone des siebenbürgischen Erzgebirges von Zám bis zum Ompolythale erforschten Höhlen, G. Téglás.

Annual report and proceedings of the Belfast Naturalists'Field Club. 1889-90. Series II. Vol. III. Part II. contains the following papers: Report of a committee of investigation on the gravels and associated beds of Curran at Larne, by R. Lloyd Praeger; A contribution to the post-tertiary fauna of Ulster, by R. Lloyd Praeger.

Festschrift zur Feier des fünfundzwanzigjährigen Bestehens des naturwissenschaftlichen Vereins zurBremen. Abhandlungen herausgegeben vom naturwissenschaftlichen Vereine zu Bremen.Band XI,Heft 1, mit 16 Tafeln. 1889. Heft 2, mit 4 Taf. 1890.

Eclogæ Geologicæ Helvetiæ. Revue Geologique Suisse pour l'année 1889, par MM. Ernest Favre et Hans Schardt.

6. *Scientific Laboratories and Museums.*

Further notes on the genusXiphocolaptes of Lesson.Robert Ridgway. (Smithsonian Inst. Proceedings of the Nat. Museum,Vol.XIII—No.796); Notes on the serpentinous rocks of Essex Co., N. Y. from aqueduct shaft 26, N. Y. city, and from near Easton, Penn., Geo. P. Merrill, (Smithsonian Inst. Proceedings, Vol. XII, No. 783); Preliminary report on the fishes collected by the steamer Albatross on the Pacific coast of North America during the year 1889, with descriptions of twelve new genera and ninety-two new species, Charles H. Gilbert, (Smithsonian Inst. Vol. XIII, No. 797.)

Bulletin from the Laboratories of Natural History of the State University of Iowa, containing: Some new species of palæozoic fossils, S. Calvin; The Loess and its fossils, B. Shimek; A new species of fresh water mollusk, B. Shimek, and other papers.

CORRESPONDENCE.

GENESIS OF THE ARIETIDÆ, BY ALPHEUS HYATT. Smithsonian Contributions to Knowledge, No.673, 4to text, 238 pp., five folio tables and 14 Plates; Washington, 1889.—Professor Hyatt begins his preface by saying: "It is a common mistake to designate my classification as *embryological.* It will be found by those who read these pages, that the whole life of the individual, and all its metamorphoses, have been deemed essential standards for the estimation of affinities. Even the degradational metamorphoses of old age are used as characteristics of value in the generic descriptions; it is properly speaking an ontological classification." (*Loc. cit.* p. VII.)

The mistake is due to the long and careful studies of professor Hyatt on the embryology of Cephalopodes in general and of the Ammonites in particular, and by the late professor Louis Agassiz saying that Hyatt was working out the embryology of the Ammonites. It is only a misuse of a term too long employed for all the work of classification at the Museum of Comparative Zoology, and which has been retained to designate briefly the starting point of the true ontological and natural classification so well advocated by professor Hyatt.

The memoir is divided into two, or more exactly into three parts. The first part comprises the Preface, the Introduction, Genealogy and Genesis of characteristics; and is devoted entirely to morphology, development, origin of forms, origin of differentials, stages of growth and decline, radical stock, etc. It is the theoretical part, written entirely in the spirit of changes in the organic world, of development and evolution inaugurated by Lamarck. As far back as 1800, Lamarck "cet

homme de génie, stoique et désinteresse" as he is called by Geoffroy Saint-Hilaire, presented his doctrine of progression, which was so much in advance of the standard of his time, that it took more than half a century for it to be truly appreciated at its real value; it was not until after the publication of the "Origin of Species" by Charles Darwin, in September, 1859, that the grand generalizations of the French naturalist began to be thought of by the new generation of naturalists; and now it is a true triumph for his long neglected doctrine of variation, to see a school, with such representatives as professor E. D. Cope, Dr. A. S. Packard and professor A. Hyatt, appropriately called "the Neo-Lamarckian."

The author of the "Philosophie Zoologique,"of the "Flore francaise," of the "Histoire naturelle des Animaux sans vertébres" and of the "Coquilles fossiles des environs de Paris," Jean, Pierre, Baptiste, Antoine de Monet de Lamarck, after being neglected for so many years, and having his reputation shadowed and almost totally obscured by George Cuvier and his school, comes out again, thanks to the careful researches of a new school, which strange to say has been educated and trained by one of Cuvier's most illustrious pupils, Louis Agassiz. It is a new example which shows how useless are all the opposition and neglect of contemporaries and adversaries, to views based on facts rightly observed and interpreted. And it is a great spectacle to witness now the rehabilitation of a naturalist,who, if he had done nothing else but his splendid work "Les Animaux sans vertébres" has left a reputation second to no one; but whose far seeing and far reaching philosophy of gradual and insensible evolution of species, places him in his right place as a naturalist of genius among the foremost great thinkers as well as great observers.

The first part of professor Hyatt's memoir, will attract the attention of all zoologists and will have undoubtedly a strong influence on young American observers, as a rare example of close reasoning, based on a great many facts well studied and carefully recorded. To be sure it is the part most open to criticism, on account of its theoretical leaning; but it is written with such candor, and the conclusions are so fairly drawn, that it will remain as a precious acquisition to our biological knowledge of a family of highly organized invertebrates.

The second part, "Geological and faunal relations,"is addressed to geologists well trained by long practical researches in the field of the lower and middle Lias. Although professor Hyatt says that "his researches where conducted almost wholly inMuseums,"he made himself well acquainted,not only with all the stratigraphy and practical work in the field of local geologists, but he studied carefully the beds of the Jurassic and Triassic systems in several of the classical areas of southern Germany and eastern France; and it is to his practical knowledge that is due the great value of his "Remarks on faunal relations." I would call attention especially to what follows: "That the North American assemblage of species has a distinct facies of its own, and ought to be separated at least provisionally from the South American

and all European faunas as the province of North America." And also, he has a provisional separation between the district of Atacamas (Chili) and the Argentine Republic, and the region of northern Peru, making two basins at least, in the Jura of the South American province.

Professor Hyatt instead of using the terms Mediterranean, Central Europe and Russia for the homozoic band of the Jurassic period used by the late Melchior Neumayr, the celebrated and much regretted professor of palæontology of the University of Vienna, in his article "Ueber climatische zonen der Jura, etc.," has adopted the nomenclature of tropical, temperate and polar homozoic bands. Certainly Neumayr's names are not well appropriated to the homozoic bands of the Jurassic period in America; only the terms of tropical and temperate are objectionable, because the tropical of the Jurassic period encroaches on the actual temperate to such an extent as to annihilate almost entirely the term temperate as it is understood in our present time; and it is more appropriate to use the terms *central* instead of *tropical*, and *neutral* instead of *temperate*, on account of the variations in the limits of those two bands in the Jurassic time when compared with the present physical conditions of the world.

Hyatt thinks that some of the basins in the Lower Lias period were capable of evolving new forms; and he named them "*Aldainic* Basins," because they were centers of origin of new series, and their faunas are called "autochthonous." He had arrived at the important "fact that the beginning of the Arietidæ was in the northeastern Alps; thence south Germany was peopled by chorological migration, and then the basin of the Jura and Côte-d'Or. Thus a zone of autochthones, or an aldainic band of basins, were formed running to the westward. North and south of this zone all faunas seem to have been residual faunas." (*Loc. cit.*, p. 89.)

After reviewing all the observations regarding the probable origin and migration of his sub-genus Psiloceras, Tmægoceras, Wæhneroceras, Schlotheimia, Vermiceras, Caloceras, Arnioceras, Coroniceras, Agassiseras, Asteroceras and Oxynoticeras, professor Hyatt has united and condensed all his facts in most interesting tables of the genealogy of the Arietidæ. Table I, for the fauna of south Germany; table II, for the fauna of the Côte-d'Or; table III, fauna of the Rhone basin; table IV, fauna of England; table V, fauna of the province of central Europe; and table VI, fauna of the province of the Mediterranean.

Those genealogic tables are the result of an immense amount of work, well digested, and clearly systematized and classified. Although professionally a paleontologist, professor Hyatt has shown in his classification and nomenclature of strata, as well as in his use of Ammonitidæ for a proper understanding of the great systems of rocks, a rare knowledge of questions which have been of late too often obscured. I mean to refer to those hybrid terms of Permo-Carboniferous, Trias-Jura, Jura-Trias, Jurassic-Cretaceous, Cretacic-Eocenal, etc., introduced

during the last twenty years. The tendency to use such expressions, which after all is nothing else, on the part of those who employ them, than an admission of their inability to arrive at the exact geological and chronological age of a certain amount of strata, is mischievous in the extreme, because it introduces into a science, which cannot exist without the most perfect chronology, a sense of uncertainty contrary to the good and proper understanding of all that relates to succession, development, evolution and geological age.

The following paragraph is most interesting on account of its precision and its well balanced classification: "The ammonoids, therefore, according to our views, are not divisible into two grand divisions, but have six suborders: the Goniatitinæ, of the Silurian, Devonian, Carboniferous, Dyas, and Trias; the Clymeninæ of the Devonian; the Arcestinæ of the Dyas and Trias; the Ceratitinæ of the Dyas and Trias; the Lytoceratinæ of the Trias, Jura and Cretaceous; and the Ammonitinæ of the Trias, Jura, and Cretaceous." (*Loc. cit.* p. 7.) According to Hyatt's view, two of the suborders of the ammonoids are special and characteristic of the Dyas and Trias, a result completely in harmony with professor Huxley's opinion of the Vertebrata. It is most important to see such paleontological observers as Huxley and Hyatt agree in placing the separation between the palæozoic and the Mesozoic below the Dyas, as it has always been advocated and maintained by all practical geologists.

The divisions used by professor Hyatt for the Lower Lias, are excellent and very complete, beginning with the Bone-bed of Quenstedt, and extending from the Planorbis beds to the Raricostatus belt. He has carefully avoided placing the Rhetic in the Lias, leaving it in the Trias, which is its proper place according to stratigraphy, lithology and a well balanced palæontology. In fact all the geological classifications used by professor Hyatt, show precision and discrimination seldom equalled in a paleontological work and which recall most happily the great geological wisdom of Barrande.

The third or last part of professor Hyatt's memoir is the most extensive, covering almost half of the volume, from page 120 to p. 221; it is devoted entirely to practical palæontology, giving the "Descriptions of genera and species of Arietidæ." He begins with the "Radical stock" first, or Psiloceran branch with the genera Psiloceras and Tmægoceras, then come the second branch with its Wæhneroceras and Schlotheimia, then the third branch with its Caloceras and Vermiceras, then the fourth branch with its Arnicoceras and Coroniceras, then the fifth branch with its Agassiceras and Asteroceras, and finally the sixth branch or Oxynoteras.

All the species described and figured are European with the exception of *Caloceras newberryi* Hyatt, from near Cerro de Pasco, Peru; *Caloceras ortoni* Hyatt, from Tingo, near Chacapoyas, northern Peru; *Arnioceras? nevadanum* Hyatt, from near Volcano, Nevada; and *Arnioceras humboldti* Hyatt, from Humboldt county, Nevada, which show beyond any possible doubt the existence of the Lower Lias in West

Humboldt range and its southern extension to Volcano in Esmeralda county, Nevada, and in Peru, South America.

In 1829, Leopold von Buch used for the first time the name *Arietidæ* in paleontology to designate a family of Ammonitinæ. Lamarck in his celebrated "Animaux sans vertèbres," in 7 vols., 1815-1822, divides the genus Ammonites of Bruguière, into only three genera: Ammonites, Orbulites and Planulites. Sowerby in his "Mineral conchology of Great Britain," 10 vols. 1818-1829, divides the Ammonites into three sections, according to the forms of the back. Von Buch with his great sagacity saw that the lobes of the chambers of the shell, were regular according to species; and combining the forms of the lobes with the exterior ornaments of the shell, he was led to divide the Ammonites of Lamarck into nine great series called by him Arietes, Amalthei, etc., etc. He began his paper of 1829: "Sur la distribution des ammonites en familles (*Ann. Sc. Nat.*, vol. XVIII, p. 417, Paris), by saying that "probably all the Ammonites can easily be classified into natural families, and that he found such an arrangement at the Museum of the University of Basel (Bale), Switzerland, under the direction of Pierre Mérian." During the years 1825-27, von Buch worked at his classification, believing that he was the only paleontologist interested in the question; when to his great surprise, during a visit at the Museum of Bale, he saw all the Ammonites classified by professor Mérian, exactly in the same order that he had arrived at in his own collection at Berlin. At first he thought he had been betrayed by somebody, but a few minutes of conversation with Mérian dissipated all his suspicions; and Mérian with a rare modesty and disinterestedness, not only did not claim any right of priority or even of equality in the discovery, but he relinquished all thought of even saying anything about it; and if von Buch had not stated the fact in his paper of 1829, it would have remained unknown. From that day von Buch and Mérian become most intimate friends and every year von Buch used to visit Mérian, once at least, often twice and even three times.

The Arietes or "Les Béliers" in French, are so well defined in the six lines consecrated to their diagnostic by von Buch, at p. 418 (*Loc. cit.*), that nothing has been changed in that family ever since by all the paleontologists from d'Orbigny, Quenstedt, Pictet, Oppel to Neumayr, Mojsisovics and Hyatt; and even his first saying that all the species of that family belonged to the Lias, has been confirmed by professor Hyatt, whose exhaustive monograph of Arietidæ shows their prevalence in the Lower Lias, with only two species of Oxynoticeras passing into the Middle Lias. Von Buch quotes only eight species of Arietidæ, in his paper of 1828, taking as his type the Ammonites turneri of the Canton of Bale; Hyatt in his description and enumeration gives no less than eleven genera, eighty-six species and numerous varieties of Arietidæ. It is hardly possible to prize too highly the excellence of professor Hyatt's plates, so well executed, with such exactness, that his work will remain a model for all future publications of Mesozoic fossils in America.

The paper is not only an honor to its author, but even more it is most creditable to American paleontology that such an important memoir has been worked out and published in America, on material mainly collected and derived from Europe. It is a rare and most valuable contribution to the paleontology of the first great group or base of the Jurassic system. Only it is so profound and it requires such an amount of special knowledge to understand all the meaning, reasoning and conclusions of the author that it is doubtful if a single person in America, besides professor Hyatt, is able to read critically every part of the "Genesis of the Arietidæ." Certainly the biological part is accessible to all zoologists and will be much appreciated, more especially by the young generation of American observers; but the geological part can be understood only by those who have studied with detail the Mesozoic faunas and the stratigraphy of Dyas, Trias and Jura in central Europe, and the number of such American geologists can easily be counted on the fingers of a man's hand.

In Europe the work of professor Hyatt will exercise the most beneficial influence, and we know already it is highly estimated by all the Austrian, Belgian, English, French, German, Italian and Swiss observers, who have devoted themselves to researches of the same sort, and although their number is necessarily limited, it is sufficient to reward professor Hyatt for his great effort in his work of progress, for his last publication has placed him in the front rank of paleontologists. J. M.

Cambridge, Mass., 15 May, 1890.

ON THE NAME "LAURENTIAN."—In the April number of the GEOLOGIST, (pp. 197-200) Prof. C. H. Hitchcock refers to a paper of mine in the January number, upon the use of *Laurentian* as applied to a Quaternary terrane. On page 197 he says: "It is to be regretted that Mr. James did not examine my reference to the publication where Mr. Desor proposed the use of the name Lawrentian." Unfortunately Prof. Hitchcock does not refer to any paper of Desor's where the word "Lawrentian" was used, either in his report on the Quaternary (AMERICAN GEOLOGIST, vol. 2, p. 303), or in the Report on the Geology of Vermont (vol. 1, p. 157.) I am glad to know, however, from the foot note reference in his article where and when the name was first used. As far as the origin of the name is concerned, there can be no question but that Desor derived it from the St. Lawrence valley, where the deposits were first studied.

On page 200 Prof. Hitchcock says, that "Mr. Desor disclaims the origination of the application of the term Lawrencian." [Lawrentian.] It should be remembered, however, that the report in the Proceedings of the Boston Society of Natural History was not written by Desor himself, but by a third person. We are, therefore, hardly justified in accepting either the language or the spelling of the term as that of Desor. But, however this may be, in other places Desor *did* claim to be the author of the term, and in these papers it was not spelled Law-

rentian nor Lawrencian, but *Laurentian* or *Laurentien*. (See pp. 30, 31 and 34 of January, 1890, GEOLOGIST)

I agree with Prof. Hitchcock that the spelling might be made to conform to the derivation of the word, and read "St. Lawrencian," although this would not be the term used by Desor Still, in this form it could be applied to a Quaternary terrane, while "Laurentian" might be used for the crystalline rocks as designated by Logan. In any event the term "Champlain" can hardly be used. It was clearly preoccupied by Emmons.

I take this opportunity of correcting two errors in the references to my paper: page 30, note 2 read *1851* for 1859; page 31, note 4, read vol. *9* for vol. 19.

JOSEPH F. JAMES.

Washington, D. C., July 1, 1890.

PERSONAL AND SCIENTIFIC NEWS.

PROF. C. H. HITCHCOCK IS ON A VISIT TO MT. WHITNEY, with a party of excursionists. In July he visited the Windward islands, Caribbean sea.

PRINCETON SCIENTIFIC EXPEDITION. A Princeton palæontological party composed of Profs. W. B. Scott, W. F. Magie, Mr. John Eyerman and six Princeton undergraduates will leave Princeton the latter part of July for a trip through the White river country of Nebraska and Dakota. Mr. Eyerman also expects to explore in south-western Colorado.

THE ROCKY MOUNTAIN CLUB, which was organized about a year ago at the University of Michigan, has been extended so as to include other northwestern institutions, and its membership now numbers about ninety. Its purpose is to visit and examine, with such care as the objects of the club may require, points of scientific and popular interest in the Rocky mountains. Its second annual excursion, under the guidance of Dr. A. Winchell, occupied two weeks in the latter half of July, leaving St. Paul on July 14.

THE MENAGE SCIENTIFIC EXPEDITION TO THE PHILIPPINE ISLANDS, started from Minneapolis July 22nd and will be engaged two years on the Islands making collections for the Minnesota Academy of Natural Sciences. This expedition is sustained by the munificent generosity of Mr. L. F. Menage of Minneapolis, and its results, if commensurate with those of others made by the young gentlemen who compose it, will be very valuable to science. Mr. D. C. Worcester and Mr. F. S. Bourns, late of the University of Michigan, and associated with Prof. J. B. Steere in a former expedition to the islands, have sole charge of this.

Very truly yours
Richard Owen.

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A SKETCH OF RICHARD OWEN.

By N. H. WINCHELL, Minneapolis.

Richard Owen, whose sudden death occurred at New Harmony, Indiana, March 24th, 1890, by accidental poisoning[1] was the youngest brother of David Dale and Robert Dale Owen, and was associated with them in many of their undertakings. He participated in some of the early geological surveys, particularly in that of Wisconsin, Iowa and Minnesota, and that of Indiana. He had long been known extensively as an author, teacher, scientist and soldier. He was born Jan. 6, 1810, at Braxfield House, Lanarkshire, Scotland, and was therefore at his death somewhat more than eighty years of age.

Dr. Owen received a training similar to that of his brother D. D. Owen, namely: tuition under a private tutor, later at the Lanark grammar school, subsequently three years (after 1824) at Hofwyl, Switzerland, where, with military drill and daily gymnastics, he acquired familiarity with French and German, and made chemistry a specialty, then again in Glasgow a full course in chemistry and physics with Dr. Andrew Ure at the Andersonian Institution. With his brother, D. D. Owen, he

[1]The death of Prof. Owen was peculiarly distressing. A jug of embalming fluid was sent by mistake to a neighbor of Prof. Owen (a merchant), labeled "medicated water." Thinking it mineral water from some friend the two drank a small quantity, and its deadly quality was soon discovered. Medical aid was summoned, but Prof. Owen succumbed under its effects, and died before midnight.

continued chemical experiments with apparatus brought by them to this country in 1827.

For a short time after arriving at New Harmony, Ind. he was engaged, though but 17 years of age, in teaching. Circumstances having placed a considerable amount of land and rent-grain, also a merchant steam flouring-mill in his hands, he conducted the same for seven years, and in this he found his former experience in farming in Lancaster county, Penn, and a three years service with his friend Dr. Wm. Price, at Cincinnati, chiefly learning malting and brewing, had supplied him a valued and adequate preparation.

Through the aid of his brother, Hon. R. D. Owen, then in Congress, he was appointed captain in the 16th U. S. infantry and remained seventeen months in Mexico, from April, 1847 to August 1848, chiefly near Monterey, with Gen. Taylor in charge of the provision trains.

On returning from the Mexican war, Dr. R. Owen found his brother Dr. D. D. Owen engaged in a survey of the N. W. Territory, and devoted the autumn and winter of 1848-9 to special preparatory training for the duties assigned him in 1849; which duty took him to the north shore of lake Superior and as high as Lake of the Woods, and consisted chiefly in making the barometrical observations, and the illustrative sketches, diagrams, &c, especially showing the remarkable trap upheavals, sometimes in basaltic arches of great beauty. A majority of the woodcuts in the body of the quarto report of Dr. D. D. Owen (sub-report by Dr.Norwood) are from the pencil of Dr. R. Owen.

Late in 1849, Col. Thornton Johnson (cousin of Hon. R. M. Johnson, vice president of the U. S.) who had organized at Drennen Springs in Kentucky the "Western Military Institute," on the plan of the U. S. Military Academy, offered Dr. R. Owen the chair of Natural Science in that institution. This he accepted and remained over nine years connected with it. During the last three years, it formed a department of the Nashville University, and was conducted, as it had been for three years previous, at the joint pecuniary expense and risk of Col. B. R. Johnson (subsequently a confederate brigadier general) and Dr. R. Owen; Col Thornton Johnson having died. But Dr. Owen foreseeing, as indicated in his Mount Vernon address, the probability of secession, in 1858 sold out his interest to

Col. Bushrod R. Johnson, The address was delivered at the request of the ladies of the Mount Vernon Association, in the capitol at Nashville and was printed in pamplet form under the title "Honor to the Illustrious Dead." While at Nashville he received (in 1858) his degree of M. D. from the Nashville Medical College after a two years' course.

On reaching his home at New Harmony, Ind., he was immediately employed in the Indiana Geological Survey, and on the death of his brother, Dr. D. D. Owen in 1860, was appointed state geologist. He was still engaged on his 8vo. report of that reconnaissance, when he was offered by governor O. P. Morton the Lt. Coloneley of the 15th Inda. vols. and accepted; reading the proof of his report, in camp, May, 1861.[1] After the battle of Greenbrier, W. Virg., Dr. Owen was promoted colonel of the 60th Ind. Vols., which he had enlisted, and remained with his regiment until Dec. 1863, participating in the capture of Vicksburg and Jackson, Miss. and in the Red River campaign. He was with Gen. Reynolds at the battle of Rich mountain and participated in the defense of the camp at Huttonsville. In the same regiment were Dr. Owen's two sons, as subordinate officers. The winter of 1861-62 he guarded at Indianapolis 4,000 prisoners captured at Fort Donnelson. In the spring of the following year he was ordered to Kentucky, and his regiment was taken as prisoners of war by Gen. Bragg at Mumfordsville. Three months later they were exchanged. Although the regiment was paroled, Dr. Owen was not, nor were his side arms taken. On the contrary Gen. Buckner went out into the field where the regiment was guarded and thanked Col. Owen for his kindness to the 4,000 Fort Donnelson prisoners at camp Morton. Gen. B. R. Johnson, with whom he had been associated as teacher, and two students, then officers in the confederate army, whom Dr. Owen had often drilled, also called on him. He was treated very politely by Gen. Bragg with whom he had become acquainted in the Mexican war.

After the exchange he was ordered to the southwest and participated in the capture of Arkansas Post. His regiment lost quite extensively in killed and wounded in this engagement. He was with Sherman in the first attempt on Vicksburg, and afterwards at the capture of the city by Grant, July 4, 1863.

[1]See p. 280 of his report: "Geological Reconnaissance of Indiana, 1860.

Soon after, in command of a brigade, he was with Sherman at the taking of Jackson, Miss. He participated with Banks in the Red River campaign, and at the attack on Banks' forces in Carrion Crow bayou, his regiment suffered severely, it having been ordered to bring up and protect the rear.

Jan. 1st, 1864, fresh from Red river campaign, Dr. Owen stood for the first time on the rostrum of the Indiana University, Bloomington, where he labored for 15 years, endeavoring to infuse into his classes a love for natural science, particularly geology, biology and chemistry. During his connection with the Indiana University he made geological reconnaissances, in 1864, in New Mexico and Arizona, also later in North Carolina, and in 1869 he visited Europe, and parts of Asia and Africa.[2]

[2]He was in Paris 15th Aug. during the centenary birthday celebration of Napoleon the First; in Athens during the visit of empress Eugenie, in Jerusalem meeting the emperor of Austria and crown prince of Prussia, all on their way to the opening of the Suez canal, 17 Nov. Dr. O. reached Port Said 16 Nov. and saw the pageant of reception for all the royal representatives of the different nationalities.

The route taken, to reach all these places, was from Vienna, after visiting Adelsberg grotto and obtaining a living Proteus (subsequently preserved in alcohol, and now in the museum at Purdue Univ. Ind.) down the Danube, thence over the Black sea to the Crimea (obtaining geological specimens from Sebastopol, Balaklava, Simpheropal, etc.) and back to Constantinople (picking up basalt on Bosphorus west of Scutari) then to Athens where he saw fine specimens of the bones of the Hipparion and Rhinoceros from the Tertiary a short distance N.W. of that city over to Smyrna with its tomb of Polycarp dating back 17 centuries; the Island of Rhodes, still exhibiting the grand fortifications erected by the Knights Templar; Syria replete with records from bible history; thence to Egypt. He describes the pyramid of Cheops as being entirely of Nummulitic limestone, of which he brought a specimen, now in Purdue Univ'y, while the pyramid next in size has a syenitic rock for its entire base, and the Sphinx is sculptured out of sandstone *in situ*, of Cenozoic age.

Returning by way of Sicily, he ascended Mount Etna, tracing the lavas of different periods; in and around Naples he examined the interesting geological records, such as mount Monte Nuovo, the temple of Jupiter Serapis, the Solfatara (bringing home from the steaming vents specimens of arsenic sulphide, etc.) thence Vesuvius, Pompeii, and Herculaneum; thence through Rome and Florence, over the Brenner Pass to Bonn, in the region of the Siebengebirge and not far from the instructive Eifel, thence through Belgium to England. In London he had fine facilities for obtaining information regarding the British Museum and Prof. (now Sir Richard) Owen's views on several moot questions in biology, being invited to his suburban villa, Sheen Lodge in Richmond Park. He had also a letter of introduction to his successor (as director of the Brit. Museum) Prof. W. H. Flower, who was then at the head of the college of surgeons.

While visiting Stratford-on-Avon Dr. Owen being acquainted with the ex-mayor of the city, Mr. Edward Flower (father of Prof. W. H. Flower) had a fine opportunity, through his courtesy, of examining

In 1874, Wabash College conferred on Dr. Owen the degree of L.L.D. and in the same year he was elected Grand Master of Indiana I. O. O. F. and subsequently Grand Representative of that order to the Sovereign Lodge of U. S. He was also an honorary member of the New Orleans Academy of Science, also of that of N. Albany Ind., and later charter member of the Ind. Acad. of Science. Being a Fellow of A. A. A. S., when the Geological Society was formed, he was enrolled as a charter member. He was elected (1872) president of Purdue University at La Fayette, Ind. but in consequence of the delay in organization he resigned in order to accept at the Ind'a Univ'y., in addition to retaining his original chair, the curatorship of the Museum. The Trustees had bought the large collection of Dr. D. D. Owen, known as the "Owen Cabinet" and made many valuable additions, besides the necessary cases through purchases from the interesting establishment of Prof. Ward of Rochester, N. Y., giving Dr. R. Owen, genial occupation in arranging, labeling, etc. Unfortunately the museum was destroyed July 12, 1883 by fire some years after Dr. O. left Bloomington, only a few of the type specimens, which were in seperate portable cases, being saved. These have subsequently formed a part of the collection in the new museum.

Dr. Owen remained at Bloomington from 1864 to the end of the session of 1879, having resigned in 1878 in consequence of impaired hearing caused by sunstroke. From that time he lived quietly at New Harmony Indiana, and on Jan. 6, 1890, celebrated his eightieth birthday.

Dr. Owen married in 1837, Miss Anne Neef, youngest daughter of Prof. Joseph Neef, formerly coadjutor with Pestalozzi, and author of two educational works. Three children were

the Lias, as several quarries exist in the neighborhood for obtaining, in that formation, a hydraulic limestone. Dr. O. states that after they have carted and dumped along the margin, say of a ten acre field, all the soil, and have quarried and removed all the available hydraulic limestone, they then return the debris and finally the soil. He saw good crops growing on fields thus treated.

While traveling in Palestine, Dr. Owen obtained at the Sea of Galilee, trachyte, amygdaloids and other volcanic rocks; also there and at the Dead sea the evidences of earthquake action were very striking. He published in "The Holy Land" (a quarterly journal,) some of these facts, and the reasons for believing that although by these catastrophes the surface of the Dead sea is now over 1,200 feet below the Mediterranean, there is evidence to show the probability that, before these convulsions, the Jordan emptied its waters through a valley still traceable from the Dead sea, past Petra to the gulf of Akaba in the Red sea.

born to them, an only daughter, who died, and two sons, Eugene and Horace, now in business at New Harmony. Dr. Owen is kindly remembered at Bloomington. His life-size portrait graces the walls of 'Athenian Hall,' and of the three new buildings of Indiana University, the one devoted to the study of natural history, which he loved so well, bears the name of Owen Hall, in his honor. "The older students of the University remember him with great respect. One reason of his eminent success as a teacher was his knack of governing young men. His idea was that young men of college age should be taught self-government, and that part of the enforcement of discipline might be left to their own management under a code formed by themselves and approved by the faculty." Dr. Owen was a member and deacon of the Presbyterian church.

Throughout Dr. Owen's works he evinces the spirit of a sincere lover of and seeker after truth. His addresses to the students of the University, his communications to the periodical literature of his time, no less than his unostentatious industry and his simple and consistent christian life, denoted the devout spirit with which he carried on all his researches.

Although the literary work of Richard Owen was bulky and multifarious, yet he did not seek the more exclusive scientific channels of publication. He desired to reach a wider audience, and produce an immediate impression. His papers may be found in educational journals, in some of the New York or Albany weeklies, in stray pamphlets and in some of the leading scientific serials of the United States. One who was his pupil at the Kentucky Millitary Institute gives a glimpse of the industrious life he spent there in the following words:

"I studied geology, natural history and chemistry under him. He also taught German and Spanish, and instructed in fencing and occasionally in dancing, and did part of the drilling in military tactics. He was always busy,—going to his room one would find him engaged in painting and drawing, and he was very good at that.[4]"

It is due to a life of so many years of labor, that some record be made here in a more detailed category, of some of the papers that he has published.

1840-41. Ten letters, on education, detailing the systems of Fellenberg, Pestalozzi, etc. *Southwest Sentinel*, Evansville, Indiana.

[4]G. C. Broadhead.

1846. Descriptions and drawings, from microscopic observations of the FlyingWeevil,a troublesome wheat pest in Indiana, *Albany Cultivator*, July and November (see also Jæger's *Life of North American insects*. p. 185).

1849. In his brother's quarto report on Wisconsin, Iowa and Minnesota a chapter, with a map, by R. Owen is descriptive of Pigeon point, Minnesota.

1857. Key to the Geology of the Globe, with numerous original maps and diagrams, A. S. Barnes & Co., New York. 256 pp. 8vo.

1862. Report of a geological Reconnaissance of Indiana (David Dale Owen, State Geologist,) By Richard Owen, principal assistant, now state geologist, pp. 368. Roy. octavo.

1864. The rock salt at New Iberia, Louisiana. *Transactions of the St. Louis Academy of Science*, vol. II, p. 250, Sep. 1864. (copied in *Am. Jour. Sci.* vol. XL, (II), p. 120.

Various articles in the *New York Tribune*, *Indianapolis Journal* and *Indiana Farmer* calculated to popularize science.

1864. Dr. Owen this year made a geological survey in *New Mexico and Arizona*, his report being printed in octavo pamphlet. (*Report on the mines of New Mexico*, by Profs. Owen and E T. Cox, Washington, 1865, 60 pp. 8vo.) A similar survey and report were subsequently made in North Carolina.

"A western glance at eastern scenes." A series of 15 letters in the *Evansville Journal* [Ind.] giving details of his foreign travel. Other letters were published in the *New York Tribune*

After leaving Bloomington Dr. Owen prosecuted his researches in physical geography and seismism. His papers are found at various dates in the reports of the *American Association for the Advancement of Science, in the Scientific American.* and the *American Meteorological Journal.* He also published a series of papers in the *Southwestern Journal of Education,* (Nashville), detailing some observations not found in works on physical geography. To these he gave the title: "Aids to the study of Geography."

He competed for the prize of 25,000 francs offered by the king of the Belgians for "The best system of popularizing geography." Of sixty competitors Dr. Owen was one of four to receive honorable mention, the prize being awarded to a German professor. Among the recommendations made in Dr Owen's essay was the employment of relief maps, since he

come common, to illustrate the natural geography of a country, and he sent to Brussels numerous specimens chiefly modeled in putty as illustrations. A full description of the methods employed with this plastic material was subsequently communicated to the *Scientific American*, and the *Journal of Education*. He also sent eighty-five original maps and many diagrams. The relief map of Europe, in four pieces, was colored geologically from the map of Sir R. I. Murchison, and was of the same size, viz: about 50 by 42 inches. After the award all the models, maps and diagrams, etc., were presented, through the American minister at Brussels, judge Lambert Tree, to the "scholastic museum," in which, according to the "Brussels Journal" of 15 Nov., 1887, they occupy a special position. Due acknowledgement was made by the Belgian minister of education.

Dr. Owen also communicated a paper to the Bologna session of the *International Congress of Geologists*, for which he received the cordial thanks of the president, Sig. Capellini.

Notices of Dr. Owen's works may be found in Dr. "Alibone's Dictionary of authors," also in "Appleton's Cyclopedia of American biography;" but a brief summary of his researches and conclusions on dynamical geology may not be out of place here. For details on these, and similar points, the reader may consult the *Proceedings of the American Association for the Advancement of Science*, at the Indianapolis, Hartford, Boston, Cincinnati, Montreal, Philadelphia and New York meetings; also the *Polytechnic Review*, New York, July and December, 1878; *Journal of the Franklin Institute*, August, 1872; *Scientific American*, March 29, 1884, and March 7, 1885; *Southwestern Journal of Education*, (Nashville), five numbers between February and December, 1888, and the *American Meteorological Journal*, (Ann Arbor), Sept., Oct., and Nov., 1886; Jan., Oct., and Nov., 1887; Nov. 1888 and Jan. and April 1889. Probably the latest of Dr. Owen's scientific publications was that prompted by an inquiry of the writer on the magnetic phenomena of a well-tube at Gordonsville, Minnesota, published in the *Standard* at Albert Lea, Minn. and dated March 8, 1890.

His seismic and dynamic researches were designed to reach at least suggestive results as to the probable causes immediate and remote, of the many changes through which our planet has passed, or is now passing, as more especially exhibited in

its crust, consequently they deal with earlier refrigeration, as well as later seismism.

1. The fundamental idea, partly set forth in the "Key," and more elaborated in later publications, was that the present configuration of land and water was to a considerable extent prefigured and determined during the earlier crust consolidation. Thus we may trace two vertical great circles, at right angles to each other; one passing, in the eastern hemisphere, through the Caspian sea, and, in the western, along the Cascade range, the other through Greenland and Japan. They divide our globe into four equal segments, each embracing a double continent: (a) Europe Africa, (b) N. and S. America, (c.) Asia and Australasia (d.) N. and S. Oceanica. Great continental trends form, with this meridional segmentation, angles of about 24°. This primal arrangement does not conflict with subsequent important changes in the position and form of continents, *within* those bounds.

The above described segmentation, as well as the continental outlining, seems connected with the two great movements of the earth: one, that of daily axial rotation, chiefly influencing or promoting symmetrical vertical, meridional, segmentation (elevation and depression); the other determining the coast trends and outlines, which in their angular divergence of 23°-24°, from the meridian, indicate a connection with the annual revolution of the earth in its orbit, inasmuch as they are perpendicular to the plane of the ecliptic, and hence remotely connected with solar influence; as well as being probably affected (in the early history of the planet, when partially fluid interiorly) by lunar tides.

2. Dr. Owen showed later that the eastern trends of the five continents (Asia, Africa, S. America, N. America and Oceanica) are 72° ($=3\times24^\circ$) apart, if we include as a continent, sinking or rising Oceanica, and that a radius of $\frac{72}{2}^\circ$ ($=36^\circ$) nearly defines the continental bounds, and passes usually through Cenozoic areas.

3. He called attention to the greater prevalence and enlarged areas of later geological formations, as we trace southerly divergence from the more restricted, northerly Archean.

4. He claims to have demonstrated that the European Alps near Monte Rosa, constituted the pole of the land hemisphere, being intermediate between the equator and its pole, between

the two fundamental great circles, and about equidistant, on any given parallel of latitude, east to the Asiatic Pacific, or west to the N. American Pacific. Farther, a majority of total seismic movements, recorded in Mallet's catalogue of 7,000 earthquakes, pass in the vicinity of that elevated epicentrum; and the same meridian is pivotal for the oscillation of the magnetic system by which the magnetic needle for middle Europe -Africa, diverges equidistantly west to Boothia Felix and, in about 333 years, east to northern Siberia.

5. This seismism has been, and still is, most readily transmitted along the strike of rocky elevations, notably mountain ranges such as the Andes and Alps, usually in great circles.

6. Dr. Owen suggested that the elevation of land is due to molecular activity in some form, and consequent mass-motion, energy which remotely is derived (in *our* solar system) from the sun; the motive cosmical origin, not only of our sun but of the stellar universe, being the result of the primal theistic, creative impulse.

"The chief *new* scientific fact which was brought out in this work, judging from its being copied into Dana's, Dawson's and Cope's works and the latest French geological work of De Lapparent, is that the general coast trend of continents, and their chief mountain ranges form angles of 23½ degrees with the meridians, the latter according with the *axis of rotation*, the trends whether east or west, being secondary to the plane of the ecliptic, according, therefore, with the *axis of orbital revolution*."[2]

Dr. Owen's lines of research were marked by originality and his conclusions, though often striking, if not bold, were put modestly before the public. He was one of the the best authorities on earthquakes, and on the location of the centers of their disturbances, and their movements in given lines.

His life, which in its voluminous correspondence with his co-laborers articulated at one end with the labors of Humboldt, Murchison, Mather and Emmons, spans an interval which has been fraught with activity and progress in all theoretical and economic science, and at its close was filled with experience and with that wisdom which length of days is sure to give to the careful and thoughtful student of nature. His education

[2]The Indiana Student, April 1886.

and training were of the old regime, and he ever manifested the scrupulousness of statement, of personal manner and of conservative caution which its influence engenders He was not a great leader, but he filled well and long various subordinate posts of duty and responsibility which fell to his charge.

THE CARBONIFEROUS AREA OF CENTRAL TEXAS.[1]

RALPH S. TARR, Austin.

CONTENTS.

I. *General Statement.*

1. POSITION OF THE FORMATION.

The Cretaceous beds in central Texas have been removed from a portion of the valley of the Colorado and Brazos rivers so as to reveal the underlying Palæozoic rocks. This region which has been called by Prof. R. T. Hill[2] the Central Deunded Area, consists in its southern portion of a very much disturbed region of older Silurian and Cambrian rocks with granite bosses and possibly Archæan Schists. Unconformably upon this is a belt of lower Carboniferous partially revealed by the erosion of the overlying unconformable upper Carboniferous. Above the latter there is Permian.

2 EROSION OF THE CRETACEOUS.

Whether the Cretaceous covered all this central area is a mooted question. There seems to be no evidence to the contrary and Prof. Hill has announced[3] the probability of such former extension. In several places the Cretaceous is found resting on

[1] Published by permission of E. T. Dumble, State Geologist for Texas.
[2] AMERICAN GEOLOGIST, Jan. 1890.
[3] Am. J. Sci., Apr., 1889, p. 284.

the Silurian; in one place, southwest of the Brady in McCulloch county, at an elevation of 2,000 feet. As the Cretaceous at this point is of the lowest division (Trinity of Hill) and as Prof. Hill has given evidence that the Cretaceous is in part a deep water formation there seems to be no question that it once covered all this region, particularly since the entire area is surrounded by a receeding Cretaceous bluff. That the Carboniferous has been uncovered from beneath a uniform mantle of Cretaceous strata is evident at first sight. Not only is it sursounded by a receding bluff of Cretaceous but tongues of Cretaceous strata extend over, and isolated buttes and very much degraded patches remain upon the Carboniferous. The so-called Santa Anna mountains of Coleman county consist of two isolated buttes of Cretaceous rock, in the center of the Carboniferous, separated from the main mass of the Cretaceous on either side by more than fifteen miles.

3. BOUNDARIES OF THE CARBONIFEROUS.

a. Probable Extent.

On the east and west of this Carboniferous area the Cretaceous beds form an almost uninterrupted boundary beneath which the continuation of the Carboniferous beds is hidden This boundary is broken west of the central portion and here the Permian occurs. Northward the Carboniferous stretches away towards the Indian Territory, and this area is undoubtedly continuous with the Carboniferous of that section. On the south is the old pre-Carboniferous land. At present there is revealed an insular patch of comparatively small size; but the evidence of the Carboniferous rocks seems to point to a former much greater extension of this Silurian area (as I shall show below) east of the Carboniferous and beneath the Cretaceous.

b. The Silurian Area.

The Silurian as at present revealed in Plano, Mason counties and adjoining counties, is a very much degraded mountainous tract of pre sub-Carboniferous age. The rocks are all metamorphosed regionally and in places by contact with the granitic area. In southern San Saba and Brady counties near the

rocks of the Carboniferous system the Silurian is chiefly marble, with much contained flint of concretionary origin. The fossils are chiefly destroyed by metamorphism, but it is easy to separate the two systems on lithologic grounds. An irregular line of contact between the Carboniferous and Silurian shows an extensively eroded pre-Carboniferous land, and the ancient shore line, with its bays, promontories and islands, presents an interesting field for study.

c. Lower Carboniferous Series.

Resting unconformably on the Silurian rocks is a narrow belt of lower Carboniferous limestone somewhat disturbed by small synclinals and anticlinals, but with a general dip of one or two degrees to the northwest, and a thickness of several thousand feet. The breadth of the strip between the Silurian and the receding edge of the overlapping upper Carboniferous varies from a few hundred yards to several miles, the linear extension of the strip being diagonal to the dip. The evidence of unconformity is given elsewhere.[4]

II. DESCRIPTION OF THE UPPER CARBONIFEROUS SERIES.

1. *Thickness of the Series.*

Above the lower Carboniferous in the valley of the Colorado river and its tributaries is a series of beds having an aggregate thickness of more than 8,000 feet in the area uncovered by the erosion of the Cretaceous. I have recently finished a detailed study of a portion of these beds, principally in Coleman, McCulloch and San Saba counties, and have made a cross section of the series from the Cretaceous on the southeast in Lampasas county to the northwestern Cretaceous in Coleman county. The entire length of the cross section is not far from seventy-five miles. North of the area is a partially continuous ridge of Cretaceous outcrop, forming the divide between the tributaries of the Colorado on the south and the Brazos on the north. Beyond this ridge the Carboniferous strikes northeast toward Indian Territory. In this area the upper Carboniferous beds, which in the southern region are buried beneath the Cretaceous, are revealed. When these are studied several thousand feet of strata will be added to the Carboniferous series.

[4] 1st Annual Report Texas Geol. Survey for 1889.

2. GENERAL STRATIGRAPHIC RELATION.

The beds of the Carboniferous have an almost uninterupted dip to the northwest. In a few places their uniform dip is slightly disturbed by very small folds, but no faults have been detected nor any large folds. At isolated places south of here, where the Cretaceous has been eroded from the Palœozoic rocks, a southeast dip has been reported. This has been taken as evidence of a broad anticlinal, but the evidence is incomplete. It is possible that the dip thus reported is connected with one of the disturbances which have occurred in this region in post Carboniferous times. Such is plainly the case in the section described by Prof. Hill, near Marble Falls.[5] So far as my observations have gone there is no evidence of an anticlinal fold. The beds may be traced from the lower to the upper in monoclinal sequence. I believe the beds were deposited to the north and west of a former much more extensive land area perhaps continuous with the older rocks of Indian Territory, and that the post Carboniferous disturbances in this region have been very slight, consisting of a general elevation with a tilting to the west. Contrary to the general hypothesis of an anticlinal I am inclined to believe that we have in this region a great synclinal trough whose western extension will be found in the Rocky Mountain uplift. My reason for this is that most of the beds of the upper Carboniferous in this section are of littoral origin, and even well up in the section considerable above the middle, are conglomerate beds with pebbles chiefly flint derived from rocks closely resembling the Silurian of the southern region. That some source other than that now visible must have been drawn upon for this supply, in part, seems evident from the fact that such conglomerates occur thirty miles north of any visible source. This leads me to suspect that a Silurian land area is buried beneath the Cretaceous east of this. The lower beds, or those near this supposed eastern area of Silurian, are coarse-grained, chiefly sandstone, and the upper beds, progressively further removed from that place, are finer. Furthermore the middle beds, followed northeast along their strike, become more and more sandy as they approach this region which by my hypothesis should be Silurian. It follows, therefore, if Silurian exists just east of this area and these beds are, as they appear, shallow

[5] American Geologist, May 1889, p. 5.

water beds derived from this shore, that the hypothesis of an extensive anticlinal is untenable. What connection this Carboniferous series bears to that of the mountains in West Texas I hope to ascertain this summer. At the present time our scanty evidence on the subject seems to indicate a central basin changed in Permian times, after a slight uplift, to an inland sea, and then, after a long period of denudation, followed by the cycles of Cretaceous deposition, and finally the grand uplift of the Rocky mountains with all its involved complication of contemporaneous disturbance and subsequent erosion.

3. DIP OF THE BEDS.

In estimating the dip of these beds considerable difficulty is encountered in determining a mean average. The dip is so gentle that the slightest disturbance by recent down-dropping or contemporaneous irregularity frequently not only lessens the dip, but even at times reverses it. In the few previous observations on this central Carboniferous area the dip has been placed at a very low figure—even as low as thirty feet to the mile. Numerous observations and a carefully drawn average have convinced me that this is much too low, and that one hundred feet to the mile is not an over estimate, but if anything something under the true dip. In my calculation I have used one hundred feet per mile as the estimated dip.

4. DIVISION OF THE SERIES.

a. Richland Sandstone.[6]

The lowest observed beds of the upper Carboniferous are sandstone with some interbedded shale and conglomerate, the whole obtaining a thickness of 4,500 feet. Without any better evidence than its uniform sandy nature and its position as the lowest division of the upper Carboniferous unconformably resting on the lower Carboniferous, this may be called the Texas equivalent of the millstone grit and the upper 3,500 feet the coal bearing beds. The sandstone of this division is

[6]The use of the word Richland needs some explanation at this place. I proposed the name San Saba sandstone, but this name was needed by another member of the Texas survey. The name San Saba used in my manuscript was accordingly changed to Richland. The new name was unfortunately chosen since the sandstone is not well developed at that point. It occupies nearly one-third of San Saba county. Owing to absence in the field I could not be consulted on the subject. The First Annual Report Texas Geological Survey, contains an announcement of this and the other division used in this paper.

a light yellow and white rock, generally quite fine grained, and containing enough iron to readily form a rusty surface, which in pieces long exposed forms a colored shell several inches in thickness. The fossils found in this division are chiefly plant impressions of the ordinary lepedodendroid and sigillaroid types and imperfect casts of lamellibranchs probably Allorisma, Myalina and the like. The scattered bands of shale are generally sandy and almost equally unfossiliferous. Some few thin beds of carbonaceous shale occur; but the outcrops invariably consist of disintegrated clay. The conglomerate bands are general local cross bedded layers of more or less brecciated pebbles of very small size so that the bed as a whole is rather a coarse sandstone than a conglomerate.

The Richland Sandstone division is terminated above by a conglomerate which I have called the Rochelle conglomerate bed. This bed which starts near the Rochelle postoffice in McCulloch county, has been traced northeast for nearly twenty miles, becoming finer grained in this direction and where it is buried beneath the Cretaceous being a coarse sandstone with cross bedded layers of fine grained conglomerate. This bed is of interest for several reasons. It is an example of progressive change in the texture from course to fine grain from southwest to northeast, quite the reverse of what is noticed in the beds above. The point of origin is plainly the southeastern Silurian, since all the pebbles are flint from these rocks, a careful search failing to reveal any other pebbles; and this is the nearest point of approach to the Silurian of any of the beds of the Richland division in this area. Near Rochelle it rests on an eroded base of lower Carboniferous, a few hundred feet thick geologically and as many yards horizontally resting on the Silurian, which is at this point a headland.

b. Milburn Shales.

Above the Richland division is the division of the Milburn shales, a series of alternating sandy shales, clay shales and one or two bands of carbonaceous shale with thin seams of coal. This series thickens to the northeast and has an average thickness of about 160 feet.

c. Brownwood limestone.

The shallow water alternating beds of the Milburn shales are succeeded by deeper water and more uniform sediments.

The total thickness of the next division, the Brownwood division, is not far from 1300 feet, chiefly (in the southern part) of limestone. On the southern portion there is one band of sandstone 25 feet thick and the remainder of the section is limestone. Much of this limestone is pure and free from foreign particles, particularly in the southern portion, but there are several bands of impure limestones with a considerable admixture of clay and in places even of sand. These beds which are marked by a dark brown rust on the surface, when traced northeastwards merge into beds of sandstone. At Brownwood there are six or eight beds of sandstone in the series instead of only one, twenty miles south of that place. It seems certain that there must have been a place of origin for this sand somewhere east or northeast of Brownwood. Beds of conglomerate in this division contain medium sized pebbles of flint resembling that in the Silurian more than thirty-five miles south of their present position, and it seems unlikely that they have been transported that far.

d. Waldrip Coal Division.

The Brownwood limestone division is followed by a series of shallow water deposits chiefly of fine sediment. This, which I call the Waldrip Coal Division, is the chief coal bearing series of the section. The lower beds are sandstone containing several thin beds of limestone. These beds, which in the southern portion are nearly two-thirds limestone, become progressively more sandy to the northeast until west of Brownwood they are fully two-thirds sandstone.[6] This thickening of the sandstone and disappearance of the limestone away from the known land area is suggestive; and more so, when, far removed from the present known Silurian, are beds of conglomerate with pebbles of Silurian flint. The beds above the sandstone are the typical coal bearing shales and clays 300 feet thick, with one seam of coal seldom thicker than twenty-four inches, and sometimes locally divided into several seams by clay partings. These beds are particularly rich in fossils of the coal series, but no detailed paleontologic study has been made. All the limestones of this and the other divisions are rich in animal remains, and in the carbonaceous shales the flora is well represented.

[6] A detailed stratigraphic description of this and the other divisions will appear in the forthcoming Second Annual Report of the Texas Geological Survey.

c. The Coleman Division.

The last division of my section is the Coleman division with a thickness of 1,700 feet to the point where it is hidden by Cretaceous. This division is almost entirely composed of numerous thick beds of limestone (100 feet) with interbedded clays and shale. The clay beds consist of thin strata of variously colored clays, (red, yellow, white and blue) with clay shales, sandy shales and thin beds of clayey limestone. The aggregate thickness of these strata rarely exceeds more than fifty feet in any one series, and both above and below will almost invariably be found a thick bed of limestone. The limestones of this division are adulterated with clay to such an extent that it is somtimes difficult to assert that the rock is a limestone. Accompanying this lithological feature is a faunal peculiarity due to the condition of sedimentation. The true limestone fauna consisting of Aythris and the like is here generally absent, and is replaced by lamellibranchs such as Allorisma and Myalina and some of the clay-dwelling gasteropods. Large species of Productus and Spirifer are sometimes abundant, but the delicate species that lived in the clear water at the time of deposition of the Brownwood beds are rarely observed. An occasional bed of sandstone is found, and these beds become more numerous to the northeast. Very likely when the strata of this division are traced further northeastward sandstone beds will be much more frequent and will have a greater thickness.

III. SUMMARY.

The history of the Carboniferous system as briefly outlined on the preceding pages commences with the deposition of a considerable thickness of lower Carboniferous limestone on an old shore of Silurian land. An interval accompanied by an elevation, a small amount of disturbance, and probably some erosion, is followed by the opening of the upper Carboniferous. Forty-five hundred feet of sandstone, shales and conglomerate included in the Richland division probably represent the Texas equivalent of the Millstone grit. Following this quite uniform shallow water deposit was a time of quiet water deposition, during which the Milburn shales were laid down with a total thickness of about 160 feet. A submergence, at least in the southwest, marks the beginning of the Brownwood

division, a period of limestone deposit in the southwest, but of more sandy beds to the northwest, which seems to point to the presence of an old land area near there, which is now hidden from view beneath the Cretaceous. The last beds of the Brownwood division indicate a return to shallow water conditions, and this is followed by the coal bearing shale beds of the Waldrip division. Following this is the deposition of alternating clays and limestones, containing much clay and a consequent change in fauna. The conditions of this deposit seem to indicate that the then shore line was in the Carboniferous, and that the Carboniferous beds previously deposited and unconsolidated were in part furnishing sediment for the forming strata. The Permian conditions are probably being approached, and possibly even at this time the basin of deposit has become a partially enclosed sea. A gap of unknown extent ensues after the close of the Permian until the beginning of the Lower Cretaceous which buried the Palæozoic rocks, now by erosion partially uncovered for study.

ON THE GLACIATION OF THE NORTHERN PART OF THE CORDILLERA, WITH AN ATTEMPT TO CORRELATE THE EVENTS OF THE GLACIAL PERIOD IN THE CORDILLERA AND GREAT PLAINS.[1]

By GEORGE M. DAWSON, L L.D., F.G.S.
Assistant Director Geological Survey of Canada.

Broadly viewed, the Cordilleran region of British Columbia and the adjoining part of the Canadian Northwest Territory to the north of that province, may be said to constitute an elevated mountainous zone bordered by two dominant ranges—that of the Rocky mountains proper on the northeast and that of the Coast ranges on the southwest. The width of this zone is about 400 miles, and on one side of it lies the wide area of the great plains, on the other the Pacific ocean together with a partially submerged outer mountain-range of which Vancouver island and the Queen-Charlotte islands are projecting parts.

In a communication which has already appeared in this journal,[2] the writer has briefly outlined the principal observa-

[1] This article may be considered as a partial abstract of a paper read by the author before the Royal Society of Canada, May 29th, 1890.
[2] Vol. III, p. 249.

tions in accordance with which he has been led to believe that this part of the Cordillera of the West was, in the Glacial period, covered by a great confluent glacier-mass. Evidence of the existence of the southern part of this great ice-mass was, at an early stage in his investigation of the glacial phenomena of the region, obtained in the corresponding part of the interior plateau of British Columbia; and though doubts were at first entertained as to the mode by which the traces of a general, as distinct from the local, glaciation of the region might be explained, these were solved at a later date.[3] Still later, the writer was enabled, while engaged in an exploration in the Yukon district, to find evidence of the northwestward extension of the same confluent glacier and approximately to determine its limits in that direction. Having thus surrounded the area of this great glacier, it was proposed to name it the *Cordilleran Glacier* in order to distinguish it from the second and larger ice-cap by which the northeastern part of the continent was at the same period more or less completely covered.[4]

The Cordilleran glacier, as thus defined, had, when at its maximum development, a length of nearly 1200 miles. The main gathering-ground or *névé* of the *mer de glace* was contained approximately between the 55th and 59th parallels of north latitude, that part of the ice which flowed northwestward having a length beyond these limits of 350 miles, that which flowed in the opposite direction a length of about 600 miles. When at its greatest, a portion of its ice also passed off laterally by gaps transverse to the Coast ranges, and filling the wide valley between Vancouver island and the mainland, the ice there divided and flowed in opposite directions as the subsidiary, but yet large, glaciers of Queen-Charlotte sound and the Strait of Georgia. Ice from the main *mer de glace* does not appear to have crossed the Rocky Mountain range proper, on the other side, though considerable local glaciers were at the same time developed on the northeastward slopes of this range.

That portion of the Cordilleran glacier which moved southeastward along the interior plateau of British Columbia, is now known, from numerous observed instances of striation crossing high points, to have covered the summits of isolated mountains of 7000 feet and over in hight; a circumstance which im-

[3] Quart. Journ. Geol. Soc., Vol. XXXVII, p. 283.
[4] Geol. Mag., August, 1888.

plies that the ice reached a general thickness of 2000 to 3000 feet above even the higher tracts of the plateau, while it must have attained a thickness of over 6000 feet above the main river-valleys and other principal depressions of the surface.[5]

The existence of this great Cordilleran glacier is naturally the first event of the period of glaciation of which evidence has been found in the region, as its ice-mass was competent to remove all signs of the more local growing glaciers which must have occurred during the early stages of the period of cold.

The object of this paper is to sketch briefly, in the first place, the subsequent history of the events of the Glacial period in this part of the Cordillera, and in the second, to endeavor to show in what way these events may be connected with those of the same period found on the Canadian great plains. In so doing it will not be possible to pursue the inductive method by which the propositions here stated have been reached, nor even to do more than to refer to the nature of the evidence upon which the various statements are based. Much of this evidence has however already been published in several papers written during the past fifteen years, and a summary of that which has not yet been made public is contained in a forthcoming more detailed memoir on the same subject. For this reason, the writer feels that he must claim the indulgence of the reader to some extent, in here advancing hypotheses without adequate proof, and without even giving in detail the reasons which have led him to modify suggestions already made by himself at various stages in the investigation.

During the maximum of the Cordilleran glacier, it appears that the Cordillerian region stood at a considerable higher level than it now does, while an important part at least of the great plains was depressed to such an extent as probably to admit waters in connection with, and at the level of those of the sea. The eventual retreat of the Cordillerian glacier was contemporaneous with, if not caused by, a subsidence of the mountain region.

The first effect of the decay of the great glacier appears to have been the production of lakes upon its surface or within the central part of the southern portion of its area, in

[5] These statements depend in part on facts published in the Geological Magazine, August, 1889; in part on additional evidence yet unpublished.

the relatively dry region of the interior plateau. Along the borders of one or more such englacial lakes, terraces, composed of material resembling boulder-clay, were formed on projecting highlands.[6] The best marked and highest terrace to which this origin is attributed, has an elevation of about 5290 feet above the present sea level, and this terrace, (or others at or about this level,) has now been recognized in a number of places. Such englacial lakes continued to increase in size and to become lower in level, for some time, while the general subsidence also progressed. There is also some evidence to show, that after the final draining of these lakes and as the great glacier retreated from the interior plateau, it was followed by gradually deepening water which was in communication with that of the sea. The boulder-clay deposit of the interior plateau is believed to have been formed during this retreat, at, or in water contiguous to, the retiring ice-front. The lower boulder-clay of the littoral was laid down under similar circumstances, but at a somewhat earlier stage in the glacial decadence, and as the submergence became deeper, stratified interglacial silts were formed above it in the same region.

The next change is supposed to have been a re-elevation of the Cordillera, during which most of the higher terraces of British Columbia were formed, and some further evidence of which is offered by the removal at about this time of much of the previously formed boulder-clay from some of the larger river valleys.[7] The land eventually stood probably as high and possibly higher than it now does relatively to the Pacific, and in consequence of its elevation and the severe general conditions of the climate of the period, it became again covered to a considerable extent by glaciers, which, however, were as a rule, of a local character and in evident relation to the various mountain ranges.

Following the maximum of this second period of glaciation, came apparently a second subsidence, less in amount than the first, but sufficient to depress the Cordilleran belt generally, to a level about 2500 feet below that which it holds at the present day. At this stage, and while glaciers of considerable size still occupied the mountain-valleys, and the position of the *névé* of the former Cordilleran glacier was probably held by an ice-cap

[6] These must at the time have resembled the *Nunataks* of Greenland.

[7] The date assigned to this removal depends on the existence and relations of the silt deposits next alluded to, in the same valleys.

of some size, the land remained nearly stationary for a long interval, and remarkable and important silt deposits, well bedded and of considerable thickness, were tranquilly laid down in different low tracts scattered along the Cordillera region for a length of about 1200 miles. These deposits, the writer has in previous publications referred to as the *White Silts*, and as observations accumulated, it at length became evident that these silts possess more than a local significance. They appear in fact to constitute a well marked formation, characterizing a definite and long maintained stage of stability in the glacial history. In the various more or less completely separated basins in which they occur, their level is so nearly identical, as apparently to show that this must be referred to a common cause, which it is believed, in consideration of all the circumstances and particularly in view of the vast area which the observations here referred to cover, can have been no other than the elevation of the sea at the time. No morainic or other accumulations have been found such as to account for the production of lakes in which these silts might be supposed to have been deposited, and had they been formed in separate lakes held in either in the manner suggested or by glacier-dams, they would, in a region of such bold relief as the Cordillera, be expected to occur at different levels in each basin.[8]

The level which is obviously the important one in dealing with this subject, is that of the upper limit of the main White Silt deposit in each basin, and in order to present the salient facts of this important episode in the glaciation of the Cordillera, the significance of which is here for the first time pointed out, the general result may be given as in the subjoined list.[9]

[8] The occurance of two such areas at the same level, under the circumstances, might be characterized as a remarkable coincidence, of three as an extraordinary coincidence and if several as a coincidence of an astounding character, unless under the influence of a common cause as here suggested.

[9] In classing together the principal occurrences of silty deposits of the Cordillera, under the name of the White Silt formation, it should be noted that the silts so included are not the only ones of the region. Occasional small and local occurrences of silts at considerably higher levels, are found, and some of these are known to be due to glacier-dammed lakes of an earlier stage. The lower level of the White Silt formation, is also to some extent indefinite, as it is probable that some portions of it were deposited in relatively deep water, while in other places, re-arranged silts have since been formed at lower levels, and these it is not always possible to distinguish from those of the original main deposit.

Normal upper level of the White Silt formation in various points of the Cordilleran region.

District.	Normal highest level in feet above sea, of main silt formation.
Columbia-Kootanie valley, between Rocky mountains and Gold ranges. (Opens to the south.)	2700.
Southern part of Interior Plateau. Silts here chiefly confined to main valleys. (opens to the south and to the Pacific.)	2500.[10]
Northern part of Interior Plateau. Silts here cover an area of about 1000 square miles. (Opens to Peace River plains and to the south.)	2400.
Peace River Plains. Silts here cover surface of plateau (In drainage basin of Mackenzie river.)	2500.
Upper valley of Stikine. (Opens to Pacific.)	2200 to 2300
Upper Liard Basin. (Opens to Mackenzie.)	2400.
Upper Yukon Basin. (Drains to Behring sea.)	2700.

The material of the White Silts was evidently afforded by streams flowing from adjacent glaciers, the approximate limits of which at the time are shown by the termination of the Silts as they approach the various ranges at levels lower than those elsewhere attained by these deposits.[11]

The evidently somewhat rapid retreat of the already reduced glaciers of the second period, was apparently not in relation to subsidence of the Cordillera, but on the contrary, seems to have been contemporaneous with, or was soon followed by, a progressive movement in elevation. It is supposed that this final decay of glaciers occurred rather in connection with a general amelioration of climate, by which the close of the glacial period as a whole was brought about, as to the cause of which no opinion is here offered.

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[10] The greatest development of silts here is below 1700 feet, which with other facts, is supposed to indicate partial local elevation, during the progress of the deposit. The upper level here given is, however, well marked.

[11] Mr. I. C. Russell, in a valuable paper entitled *Notes on the Surface Geology of Alaska*, proposes to name the body of water in which the silts of the Lewes have been laid down, 'Lake Yukon.' Holding as I do that this water was not that of an isolated lake, I would suggest the name 'Yukon Inlet'. The silt formation on the Lewes has an upper limit of about 2150 feet, while in the contiguous region of the Upper Pelly, the limit is found at 2700 feet, as given above. The lower level of the higher part of the formation on the Lewes, I believe to be due to the fact that the whole upper portion of this valley was occupied by glacier-ice at the time of its deposition. Cf. Report of Progress Geol. Surv. Can., 1877-78 p. 153 B; Annual Report Geol. Surv. Can., 1887-88, Part B; Bull. Geol. Soc. Am., Vol. I.

It is worthy of note, that most of the long fiord-like lakes of the mountain regions of British Columbia, can be shown to occupy portions of the abandoned beds of the glaciers of the stage of the White Silt formation. To the elevation which began about the time at which we have now arrived, the draining of the White Silt basins, together with the formation of all the lower-level terraces, is supposed to be due. There appears, however, to have been one well marked pause, during which the littoral, at least, was at a hight about 200 feet lower than it now is, and there is in addition some evidence of a succeeding movement in elevation of several hundred feet, which, if it occured, constitutes the last important change of the kind in the region.[12]

Having elsewhere discussed the glaciation of the great plains at some length, [13] the writer may now without attempting any further description of the phenomena which they present,offer the subjoined comparative scheme of events in the areas of the plains and the Cordillera respectively. Under this scheme, he has endeavored to include all the known facts and to deal with these in the light of personal familiarity with the greater part of both regions, and while it can scarcely be hoped that this scheme, here tentatively presented, will be found to stand the test of further investigations in all its details, it is believed that it may at least be accepted as indicating the mode in which the facts met with must be explained. In explanation of the fundamental idea involved in this comparison it may be premised, that already in Tertiary times some evidence is given of correlative phases of elevation and depression as between the Cordillera and the great plains, and these, it is believed, may have culumiated in a series of important correlative movements during the Glacial period, in which the plains were in a position more or less exactly complementary to the Cordillera. The general application of such correlative movements in the Glacial period, has lately been forcibly advocated by Mr. Warren Upham [14], and appears to the writer to hold

[12] Cf. Canadian Naturalist, February 1878.

[13] Geology and Resources of the 49th Parallel, Chapters IX and X; Quart. Journ. Geol Soc., Vol. XXXI p. 603., Vol. XXXVII, p. 276; Report of Progress Geol. Surv. Can., 1884-85, p. 139 C. See also R. G. McConnell, in Ann. Report, Geol. Surv. Can., 1885, Part C., and J. B. Tyrrell Ann. Report Geol. Surv. Can. 1886, Part E.

[14] Wright's Ice Age in North America. Appendix A.

out the prospect of a solution of many of the difficulties which have so far attended the explanation of the facts of this period.

Scheme of Correlation of the Phenomena of the Glacial Period in the Cordilleran Region and in the Region of the Great Plains.

Cordilleran Region.	*Region of the Great Plains.*
Cordilleran zone at a high elevation. Period of most severe glaciation and maximum development of the great Cordilleran glacier.	Correlative subsidence and submergence of the great plains, with possible contemporaneous increased elevation of the Laurentian axis and maximum development of ice upon it. Deposition of the lower boulder-clay of the plains.
Gradual subsidence of the Cordilleran region and decay of the great glacier, with deposition of the boulder-clay of the interior plateau and the Yukon basin, of the lower boulder-clay of the littoral and probably also, at a later stage (and with greater submergence) of the interglacial silts of the same region.	Correlative elevationof the western part, at least, of the great plains, which was probably more or less irregular and led to the production of extensive lakes in which interglacial deposits, including peat, were formed.
Re-elevation of the Cordilleran region to a level probably as high as or somewhat higher than the present. Maximum of second period of glaciation.	Correlative subsidence of the plains, which (at least in the western part of the region) exceeded the first subsidence and extended submergence to the base of the Rocky mountains near the 49th parallel. Formation of second boulder-clay, and (at a later stage) dispersion of large erratics.
Partial subsidence of the Cordilleran region, to a level about 2500 feet lower than the present. Long stage of stability. Glaciers of the second period considerably reduced. Upper boulder-clay of the coast probably formed at this time, though perhaps in part during the second maximum of glaciation.	Correlative elevation of the plains, or at least of their western portion, resulting in a condition of equilibrium as between the plains and the Cordillera, their *relative* levels becoming nearly as at present. Probable formation of the Missouri côteau along a shore-line during this period of rest.
Renewed elevation of the Cordillera region, with one well marked pause, during which the littoral stood about 200 feet lower than at present. Glaciers much reduced, and diminishing in consequence of general amelioration of climate towards the close of the Glacial period.	Simultaneous elevation of the great plains to about their present level, with final exclusion of waters in connection with the sea. Lake Agassiz formed and eventually drained toward the close of this period. This simultaneous movement in elevation of both great areas may probably have been connected with a more general northern elevation of land at the close of the Glacial period.

Referring to the several correlative movements of elevation and of depression of the Cordillera and the great plains, above

set forth, it may be admitted on *à priori* grounds as not improbable that such conditions of oscillation once initiated, in consequence of the interaction of whatever forces, might have a tendency to repeat themselves several times before a stable condition was regained,—a state of equilibrium being in the end attained either by the general decrease in intensity of the operating causes, or by the final ascendency of one class of these. It may also be pointed out that the supposed sequence of events is generally in accordance with the view that the epochs of maximum glaciation of the Cordillera, were those of its greatest elevation, while the decay of its glaciers was in both instances accompanied, if not caused, by subsidence leading to the encroachment of the oceanic waters. The supposed flooding of the great plains (the glaciated portion of which lies almost entirely in the Arctic basin) by cold northern waters, while the Cordillera stood as a much elevated land between these and the warmer waters of the Pacific, in itself goes far to explain the conditions under which the excessive precipitation required for the production of the Cordilleran glaciers might occur.

The sequence of events here advanced is furthermore compatible with the belief that the weight of a ponderous ice-cap may alone be sufficient to produce subsidence of the land, and with the idea that such an ice-cap may thus eventually become self-destructive, by obliterating the elevation to which its existence is in the first instance largely due.

Though independently based upon, and primarily intended to include the observed phenomena of the Glacial period in the northwestern part of the continent alone, it is also worthy of remark, that the elevation believed to have affected the Canadian plains during the interglacial episode, is to some extent confirmed by the fact that Messrs. Chamberlin and Salisbury find evidence of a similar upward movement of the upper Mississippi valley at a corresponding time, to an amount of about 1000 feet.[11] It is further noteworthy that the two great correlative movements of elevation of the Cordillera and depression of the great plains here admitted, correspond in a general way with the principal similar, though less considerable, changes in level, which are accepted by Mr. W. J. McGee as explaining changes which affected the region of the middle At-

[11] Sixth Annual Report U. S. Geol. Survey, p. 214.

lantic slope, and indicated there by the Columbia formation.[15] As in the case of the great plains, both changes in level were there in the sense of depression, followed by re-elevation, but if we may believe that depression in one region is made up for by elevation in another, the only important point to which attention need be drawn, is that both maxima of glaciation, on the Pacific as well as on the Atlantic side of the continent, were coincident with considerable disturbance in level.

It may be added in conclusion, that it is now distinctly known, as the result of work done under the auspices of the Geological Survey of Canada, and more particularly of observations by the writer and his colleagues, Messrs. McConnell and Tyrrell, that the extreme margins of the western and eastern glaciated areas of the continent barely overlap, and then only to a very limited extent, while the two great centers of dispersion were entirely distinct.[16] For numerous reasons which can not be here entered into, the writer does not consider it probable or even possible that the great confluent glacier of the north-eastern part of the continent extended at any time far into the area of the great plains, but erratics and drift derived from this ice-mass did so extend and are found between the 49th and 50th parallels stranded on the surface of moraines produced by the large local glaciers of the Rocky mountains. Recognizing, however, the essential separateness of the western and eastern confluent ice-masses, and the fact that it is no longer appropriate to designate one of these the "Continental glacier," the writer ventures to propose that the eastern *mer de glace* may appropriately be named the great *Laurentide glacier*, while its western fellow is known as the *Cordilleran glacier*.

NOTES ON THE CHARACTERS OF THE ERUPTIVE ROCKS OF THE LAKE HURON REGION.

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The material for the following notes is based on the field relations, and microscopical characters of eighty specimens of the dikes and other irruptive rocks observed during a trip around lake Huron, in a small boat, in the summer of 1889.

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[15] Seventh Annual Report U. S. Geol. Survey, p. 639.
[16] Cf. Geol. Mag., Dec. III, vol. v, p. 250.

The exposures of Laurentian gneiss, forming the whole of the eastern and northern sides of Georgian bay, as far as the village of Killarney, are remarkably free from regular dikes. There were noticed however, two occurances of an apparently irruptive rock of much interest: a small bare island just above the water, four miles north west of Bushby inlet, is formed of a dark massive rock, very different from the gneiss of the surrounding islands. Under the miscroscope it is seen to consist largely of a deep green strongly pleochroic hornblende, in exceedingly irregular crystals or leaf-like aggregations. The centres of the crystals appear of a dull color and are rendered nearly opaque by thickly clustered minute grains of magnetite arranged along the cleavage lines of the former augite crystals. Large grains of magnetite are associated with the hornblende as, also, are numerous biotite leaflets and garnets; these are all embedded in a water-clear granular matrix of quartz and indistinctly twinned feldspar.

A little north of Bing inlet occurs another rock of similar aspect, cutting the gneiss in an irregular manner. Under the microscope this shows a very interesting character, and though the constituents appear to be secondary, yet its derivation from a diabase is evident, and illustrates how completely the primary minerals may be removed and yet their form preserved. Garnet, magnetite, mica, quartz and epidote are the most important constituents; Dark, nearly opaque, masses polarizing in deep blue and purplish tints and allotriomorphically developed are decomposition products of augite. Penetrating these dark masses are angular spaces exactly corresponding in form and arrangement to labradorite crystals in diabase, and filled with paramorphs of garnet aggregates. The open spaces between the alteration products of augite are filled partly with elongated rectangular aggregations of garnets, and partly by granular quartz, epidote, mica, and aggregations of green microlitic bodies. In many of the garnet aggregates are quartz grains and an interlacing net-work of green microlites. Lines of garnet surround all the dark augite alteration products and mica and garnets border the large irregular magnetite grains; scales of mica are often enclosed in the magnetite.

Three miles east of Killarney, near the junction of the quartzite with the Laurentian gneiss, appears the first unmistakable dike intercalated with a fine granulite whose strike

is a little south of west. Labradorite, augite, magnetite and apatite needles are the only constituents. The labradorite crystals are beautifully twinned, and show the beginning of decomposition into a green fibrous substance; or perhaps rather a migration of the decomposition products (actinolite?) of the augite within the plagioclase. Many do not extinguish simultaneously for on revolving the stage light and shadow sweep across from one side to the other or from the centre outward. The augite shows polysomatic crystals; and the magnetite presents crystalline outlines suggesting, though by no means proving, it to be primary.

Five miles westward on Badgely island, a dike of precisely the same microscopical character intersects a granitoid rock in an east and west direction; this may be a continuation of the one just described though somewhat wider and having near its southern edge two narrow dikes; one a foot wide the other three feet. This dike illustrates well the the usual character of a mass irrupted through a cool rock: it is coarse in the centre, much broken into rectangular blocks by jointing planes, while at the sides it is aphanitic.

For sixty miles no more normal diabase dikes are seen. Numerous altered diorites are met along the shore or on the islands. Some are only a few feet wide, others fully a mile across. These extend more or less continuously westward from Cloche island, forming the whole or simply the northern sides of many of the chain of islands as far as six or eight miles beyond Spanish mills. This altered diorite, whether in an occasional narrow branch intersecting quartzites and schists or in its great mass, exhitits a remarkable uniformity over its whole extent, showing quite uniform composition, texture, and degree of alteration. The main body is intercalated with the schists which have a very constant east and west strike and vertical dip. Between this irruptive rock and the bedded schists is usually a dark, soft layer of chlorite schist, resulting evidently from movement and pressure. In one place only were the strike and dip of the country rock noticed as being disturbed, this was ten miles west of the Wallace mine where thick-bedded quartzite forming a small island has a dip of but 45°. Directly adjoining this is a large, high island consisting entirely of diorite which is, evidently, the cause of the unusual dip.

Microscopic examination of sections from various portions of this great eruptive mass as well as from several narrow dikes east of Cloche island shows in most instances a highly decomposed diorite. In only a few instances is there any appearance of the derivation of the hornblende or the chlorite, into which it is largely decomposed, from any preëxisting augite. A section from a narrow dike in the granite a little north of Killarney shows a micaceous diorite containing much brown mica; some uralitic hornblende, the rest bleached and fibrous with dark green borders; small twinned plagioclase crystals; granular epidote, and pyrite. The mica scales and green hornblende are often mixed indiscriminately.

Another narrow dike, in sericite schist on the long peninsula south east of Cloche island, under the microscope shows a uralitic hornblende schist. The hornblende crystals polarize in deep green to yellowish tints, are irregular in outline and terminate in long actinolite like fibres. The fine granular matrix between the large crystals is filled with similar long green fibres, mica scales, and a little magnetite. Basal sections show hornblende cleavage. In the centre of the large crystals are dull circular spaces dotted thickly with granular magnetite, traces perhaps, of preëxisting augite. Sections from two dikes south-west of Wallace mine, exhibit a pale green chloritic hornblende, granular in the centre with bright green fibrous edges; magnetite grains dot the cleavage cracks, and the feldspar crystals are largely clouded. A dike intersecting a high quartzite knob contains a large proportion of deep green, fibrous hornblende, similar to the uralitic hornblende schist just described. The feldspar is dotted with aggregations of granular epidote; and ilmenite in small opaque granules with cloudy (leucoxene?) borders is present in small quantity. The next half dozen sections are taken at intervals from the extensive exposure of massive diorite, before described as forming a large part of the islands for so many miles. These sections are so nearly alike that one description will do for all. In the most of them, alteration has proceeded so far that simply a confused mass of secondary products appears. The viriditic or chloritic constituent, in irregular, pale green or almost colorless crystals, represents former hornblende; judging from numerous basal sections. These bleached fibrous crystals show such an indefinite character it is often difficult

to distinguish from among them the decomposition products of the feldspar crystals, whose outlines are nearly gone, and are represented partly by epidote and partly by akaolinic product with a little granular calcite. Many sections show ilmenite grains with cloudy borders, and numerous small bright, orange-red granules or crystals which as nearly as can be determined are rutile. There is also some secondary quartz and orthoclase.

A very peculiar vein or dike occurs in the diorite a few miles west of Spanish mills. Thin sections shows it to be a micaceous pyroxene schist exhibiting the following minerals: a rhombic pyroxene, biotite, quartz, magnetite, chlorite and serpentine. The pyroxene crystals show strong pleochroism, are very much broken, irregular and somewhat altered, so that the cleavage is indistinct, yet the general appearance is that of hypersthene. Numerous large scales of mica are partly in good condition and partly altered to a brownish or greenish, almost amorphous substance, full of numerous opaque needles and grains. Fine granular quartz forms the body of the rock.

About eight miles west of Spanish mills granite and gneiss again take possession of the shore and islands. On the mainland northwest of Bird island appear several elongated, rectangular masses of diorite enclosed in granite. They have a perfectly fresh appearance. A strongly pleochroic hornblende, often in well formed crystals is mingled with about an equal amount of plagioclase and a little magnetite and quartz.

A dike of typical olivine diabase, three hundred feet wide, appears to the westward. It lies in an east and west direction and is intercalated with gneiss. To the naked eye it could not be distinguished from the diabase exposure at Killarney, but under the microscope is seen to vary somewhat. The augite is in almost perfect condition and as usual, is allotriomorphically developed, exhibiting pale brownish color, strong double refraction and rough section surfaces. The feldspars show beautiful twinning and are sometimes entirely enclosed in the augite. Many of the crystals show extinction successively in successive portions. Inclusions of long apatite needles are very abundant. The form of the magnetite crystals often appears to be conditioned by that of the feldspar, showing that the feldspar crystalized first. Considerable olivine, sometimes showing crystalline boundaries, but more often

granular, is scattered over the section; many of the grains are undergoing decomposition on their borders into green serpentine and magnetite.

A narrow diorite dike west of Cook's mills shows a complete alteration similar to that before described. Basal hornblende cleavage is often shown in the chlorite.

On a series of small islands, two miles west of Algoma Mills another completely altered diorite appears which contains some secondary quartz and orthoclase, as well as the usual decomposition products. Another dike similarly decomposed just east of Blind River mills, is characterized by a large amount of leucoxene containing stringy portions of ilmenite.

The four following sections are from one of a number of similar dikes extending in a direction a little south of west from Blind river and forming the back bone of a number of islands. These sections exhibit the usual variation between a coarse centre and an aphanitic edge. The two sections taken from nearest the centre and the one from the edge are completely altered. The feldspars are represented by cloudy aggregates, and the augitic constituent by a confused mass of pale green or yellowish appearance, bordered in places by green hornblende. There is also much granular magnetite and leucoxene. The fourth section, taken a few feet from the edge is not so much decomposed and gives the key to the original composition of the whole mass. Decomposition, as with the others, has formed much dirty green matter, magnetite and a clouding of the feldspars. But the centres of many crystals of augite appear in good condition, showing basal cleavage and usual polarisation colors. The dike cuts across the strike and bedding of the quartz schists at a small angle, lacking about twenty degrees of being vertical.

Contact metamorphism of the schists is finely illustrated by their vitrification for several feet on each side.

The shore line from this point to within about three miles of Thessalon, a distance of perhaps twenty-five miles, is occupied by a granitoid rock, containing in many places angular inclusions of foreign material which together with a sort of flowage structure presents the appearance of a semi-eruptive mass. Narrow dikes occur at short intervals and as a general thing lie in a direction approximating east and west. About four miles west of the mouth of Blind river, a large irregular-

ly bounded mass of diorite seems to have broken through the granite and in places the red coloring matter of the latter is blended with the eruptive rock. Sections from the various portions show, as usual, a high state of alteration. In one in particular the forms of the feldspar crystals are scarcely discernible, while distinct, four to six sided crystals of chlorite and others of granular epidote, seem to be paramorphs after hornblende.

Two sections of dikes a little to the east show very distinctly the effects of pressure in the broken and crushed feldspar crystals. The cracks are filled with chlorite. One of the sections shows crystals of leucoxene altered to titanite. Proceeding westward toward Thessalon the various dikes met, with few exceptions, are greatly altered, and exhibit a very similar appearance. In some there is a deep uralitic hornblende; in others it is chiefly viridite; a little magnetite or ilmenite with leucoxene and rutile often appear; and occasionally apatite needles. One dike deserves mention as it contains hornblende which has every characteristic of primary origin, being in distinct pleochroic crystals.

Three miles east of Thessalon three sections were obtained from a dike intersecting a basal Huronian conglomerate. They do not show much difference in texture between the middle and the edge and are very much altered. The section from the centre contains a large amount of calcite in granular aggregations; plagioclase, partly decomposed; chlorite, apatite needles; quartz; and numerous opaque and cloudy granules, referable perhaps partly to magnetite and partly to ilmenite. The specimen intermediate between the centre and the edge contains long, jagged, opaque needles like ilmenite, also some mica, in addition to the minerals of the other section. That from the edge contains long lath shaped crystals of plagioclase mostly clouded and cut up by numerous small epidote crystals and has instead of ilmenite many crystals somewhat granular and cloudy but otherwise closely resembling titanite.

A quarter of a mile west of this point a mass of eruptive rock begins, and extends along the shore continuously to Thessalon. This presents a uniformly, fine aphanitic texture often amygdaloidal, and in places on the upper surface where the amygdules have decayed out, shows a highly scoriaceous

character, reminding one of the lava overflows of the western states. Near the eastern border this mass presents a jointed and somewhat slaty appearance. And a mile east of Thessalon, portions are so soft as to resemble chlorite schist. The amygdules are usually calcite, epidote, or quartz. The quartz is not often amorphous but in fine granular mosaics, with the grains arranged concentrically around the cavity; the coarser in the middle. Some of the larger cavities contain agates. Angular or rounded fragments of felsite and granulite stand out distinctly in numerous places. Rounded pebbles of clear quartz, several inches in diameter, occur frequently, presenting no signs of secondary origin. At one spot a more modern dike cuts this old eruptive formation. It is fresher looking but contains the same constituents.

Ten sections made from various portions are almost identical in composition though they show considerable variation in the degree of alteration and in texture. The components are not distinguishable to the naked eye, but under the microscope show minute interlacing crystals of plagioclase usually clouded; and alteration products consisting of chlorite, viridite, epidote, calcite, and sometimes mica and leucoxene. Two sections show a microfelsitic texture; and in one are large crystals of feldspar of previous generation.

Whether the original state was that of a melaphyre or basalt, it is impossible to say. Logan applies the term "chlorite slate" to this mass of rock, which is very misleading, for it is plainly a lava overflow with no traces of stratification.

Quartzite is met again a short distance west of Thessalon and on several islands it is intersected by dikes having an east and west direction. The first is a coarse diabase much altered, the augite being mostly changed to uralitic hornblende, mica and viridite. The feldspar crystals are largely clouded; the unaltered portions show successive extinction similar to that noticed in diabases farther east. The magnetite is usually surrounded by a layer of biotite mica. A section from the edge of this dike shows lath-shaped labradorite in good condition, and much magnetite and alteration products. On an adjoining island, appears a dike quite similar to this, though not so much altered; the augite is in polysomatic crystals, and often bordered by green hornblende. One of the largest crys-

tals has terminating within itself a long, narrow, rod-like crystal of augite which is differently oriented.

A mile westward appears an interesting rock which in thin sections shows a very pretty pegmatitic structure. Small angular lamellæ of quartz with the same orientation over considerable portions of the section, penetrate a decomposed feldspar or other alteration products like epidote and viridite. Portions of the section contain uralitic hornblende, and appear like highly altered diabase.

A very fine aphanitic dike six inches wide intersects an altered diorite a little farther westward on the main land. Under the microscope appears a net work of interlacing and very minute and acicular plagioclase crystals with jagged ends. These are imbedded in a micro-felsitic matrix which is rendered nearly black by minute opaque grains.

Five miles west of Thessalon is an altered dike probably an old diabase. It cuts across the strike of the quartzite nearly east and west. It is somewhat schistose in the direction of its length. It has rendered the quartzite bedded in the same direction for at least ten feet away. This slaty structure of the quartzite is so pronounced that in weathering it breaks off in slabs parallel to the dike. That a great strain and movement took place subsequent to the time of injection is shown by the presence of a breccia, five or six feet wide bordering the dike. It consists of a mixture of angular fragments of the eruptive rock and of the quartzite, imbedded in a matrix of quartz and chlorite.

Beginning a short distance west of this point, the shore and islands are formed of a dark massive rock, an altered diabase of coarse texture. A thin section shows a dull colored mass in which the form of the greenish plagioclase crystals can be distinguished. Some quartz containing apatite needles forms a pegmatitic structure. Most of the alteration products are of such an indefinite character that they cannot be made out. This rock extends as far as the Bruce mines and forms the island in the bay.

Continuing westward up the channel toward the head of St. Joseph's island, we pass several dikes. The first one of any particular interest being opposite the light house west of Campement d' Ours island. It shows a peculiar pegmatitic structure; large crystals of twinned plagioclase are pierced by hie-

roglyphic-like quartz lamellæ. The lamellæ penetrating any one crystal of feldspar have the same orientation, while those penetrating different crystals have different orientation; green chloritic hornblende dotted with magnetite, forms irregular masses and in some cases seems to penetrate the feldspar in a manner similar to that of the quartz. Apatite needles are thickly scattered through the quartz.

On the islands east of the lower end of Sugar island, are a number of dikes extending in a northwesterly direction. They were probably all originally diabase. All degrees of alteration are visible in the sections, from those still showing a fair condition of the augite and feldspar to those in which the alteration products form an almost indeterminable mass.

Distinct types of eruptive rocks along the north shore are very few. A large number of the dykes are evidently diabase; many are alterations from that, or an allied type; and some appear as either normal diorites or alterations from that type. In addition, there are some of basalt or melaphyr.

An interesting feature about the main dikes is the general east and west direction. Whether this is due to the strike of the schists offering the least resistance in their bedding planes or some line of strain in accordance with which their directions were determined, it is impossible to say.

The large exposure of eruptive rock east of Thessalon is evidently an old overflow, judging from its uniform fine texture and often amygdaloidal character. The other two large areas of eruptive rock give no evidence of surface consolidation, appearing simply as enormously expanded dikes. The scoriaceous character of parts of the Thessalon eruptive seems to indicate that, either, our generally conceived notions of the great amount of pre-glacial and glacial erosion are exaggerated or what is more probable, as suggested by Dr. Lawson, palæozoic sediments have covered portions of the Archæan rocks, and preserved them from erosion, and in this region, perhaps, till the glacial period, for it is but a short distance to the Silurian rocks which form the islands in the channel.

One of the most difficult problems for solution, in the study of these ancient eruptive rocks, is the determination of their original constitution and the genesis of the present altered forms. The dikes are probably all of Archæan age. They are at least pre-Silurian for the limestone which, in many places,

can be seen resting upon the quartzite or gneisses is not at all disturbed. The dikes showing the greatest degree of alteration occur, both in the Huronian quartzite and siliceous schists and in Laurentian gneiss, while the freshest and most perfect examples met were in the Laurentian gneiss.

If we attribute the very great amount of alteration, exhibited by the extensive body of massive diorite in the vicinity of Spanish Mills to crushing or deformative forces or penetrating water, we must separate its origin in time from the unaltered diabases, in the immediate vicinity, by an immense period, sufficient for the conversion of augite into hornblende and that hornblende into viridite. And these forces must have entirely ceased before the injection of the unaltered diabases. One can hardly believe in such a sequence of events for some of these eruptive, for example the mass of diorite just mentioned. From microscopic examination and field relation there appears no clue to the action of those forces, which is evident, have usually brought about the alteration, during foldings of the strata, of narrow or interbedded masses of trap rock of no great extent. It seems to me we can attribute to some of these bodies of eruptive matter such conditions at their solidification as would favor the formation of hornblende, in others that of augite; and in special cases, with certain other conditions of solidification in which moisture in some form is present in the cooling mass, the formation of primary hydrated minerals; or at least give rise to a rock whose composition and method of solidification have endowed it with an inherent tendency to decay.

T. S. Hunt in speaking of chlorite, in some granites says it indicates the presence of water in the original liquid magma. And could not the same conditions be conceived as existing in other rocks solidifying from fusion. Granting that such a condition may exist under favorable circumstances, we have a more rational method of arriving at the original condition of some of these rocks, than to attempt to carry their history back through several changes to one fixed original type in which augite plays the principal part.

Geological Labratory, University of Mich., March 4th 1890.

NEW LAMELLIBRANCHIATA.

By E. O. ULRICH, Newport, Ky.

No. 2, On two new genera and six new species.

Ischyrodonta, n. gen. [Ety. *ischyros*, strong, *odous*, tooth.]

Short or elongated, thick bivalve shells, having small subterminal beaks, with the hinge straight or slightly arcuate and extended posteriorly. Hinge plate wide and strong, without posterior lateral teeth, but with a strong cardinal tooth in the left valve and two nearly as strong in the right. Just in front of them a pair of subcircular large and deep anterior muscular impressions, and between these and the teeth another very small pair. Posterior scar large but faintly marked, ovate, situated in the postero-cardinal region. Pallial line simple. Ligament probably internal.

In casts of the interior the beaks are prominent and compressed, and a well defined sulcus, representing a ridge-like internal thickness of the shell, extends from the umbones more than half the distance to the basal margin. Type, Ischyrodonta truncata, n. sp.

The internal casts of the two species of shells for which the above generic name is proposed, remind one of both *Cypricardites* Conrad,and *Modiolopsis* Hall,the position of the new genera being, perhaps, very nearly intermediate between these two genera. From *Cypricardites*, which they resemble the most in the general form, thick shell, and wide hinge plate, they differ in having no posterior lateral teeth. The cardinal teeth are also less numerous, stronger, and differently arranged. From *Modiolopsis*, of which they likewise resemble certain species in their general aspect, they differ in having a thicker shell, wider hinge plate, and much stronger cardinal teeth. In true *Modiolopsis* there is only a mere thickening or slight fold of the hinge plates beneath the beaks, yet I do not think that the plan of hingement is fundamentally different from that of *Ischyrodonta*, in which I believe it has simply found more full expression. The small accessory scars situated just above the anterior adductors, are not, as far as I am aware, ever present in either *Modiolopsis* or *Cypricardites*.

Ischyrodonta truncata, n. sp.

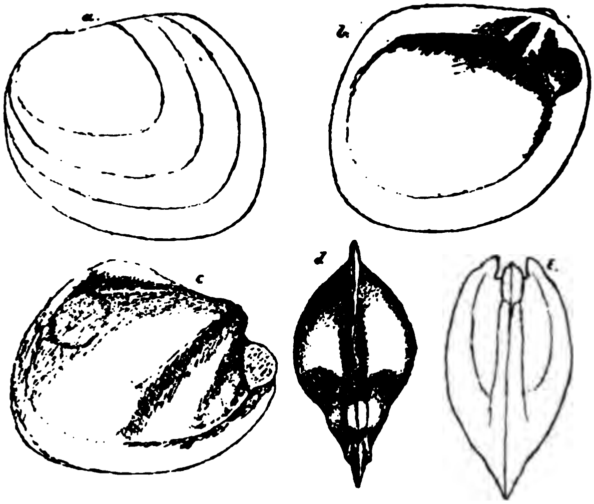

Fig. 11. *Ischyrodonta truncata*, n. sp., Cincinnati group, Oxford, Ohio. *a*, outline view of a left valve of this species, slightly restored. *b*, internal view of same, showing only the hinge plate, cardinal teeth, and anterior muscular impression, the cavity being filled with adhering matrix. *c*, *d* and *e*, three views of a very nearly perfect cast of the interior. Between the beaks of the central figure is shown a thin film of stone that had originally filled a narrow interstice between the hinge plate and cardinal teeth.

Shell of medium size, moderately convex, subquadrate to broad-oval, widest posteriorly. Cardinal margin straight or faintly arcuate, nearly as long as the shell. Anterior end very short, rounding uniformly into the convex basal margin. From here the edge makes a sharp turn (in the post-basal region) into the somewhat truncate but convex posterior margin, meeting the posterior extremity. Surface of the thick shell smooth between a limited number of impressed lines of growth.

Hinge plate thick and wide, flat; the cardinal teeth strong. Anterior muscular impression deep, its outline somewhat top-shaped, pointed below where the well marked pallial line runs into it. Posterior scar very faint, large, subcircular, situated near the postero-cardinal angle. In casts of the interior the beaks are prominent, compressed, while a well marked furrow extending from the beaks nearly to the center of the base, gives rise to an obtuse umbonal ridge of which no sign is apparent

on the exterior of the shell. Another but less deep and shorter furrow occurs in the space between this and the anterior muscular scar.

An average specimen of the typical form has the following dimensions: Greatest length, 35 mm.; greatest hight, (from posterior extremity of hinge line to posterior portion of base) 30 mm.; from postero-cardinal angle to antero-basal region 31.5 mm.; from beaks to postero-basal region 35 mm.; greatest convexity of a cast of the interior of a specimen of the same size, 16 mm.

This species ought not to be confounded with any other known to me from the Cincinnati rocks. I have seen specimens of it labelled *Cypricadites hainesi* S. A. Miller, a shell occupying the same horizon, but there is little reason for confusing the two since Miller's species has posterior cardinal teeth, is less convex, and not so high posteriorly.

Position and locality: near the top of the Cincinnati group at Oxford, O., and Richmond, Ind.

Ischyrodonta elongata, n. sp.

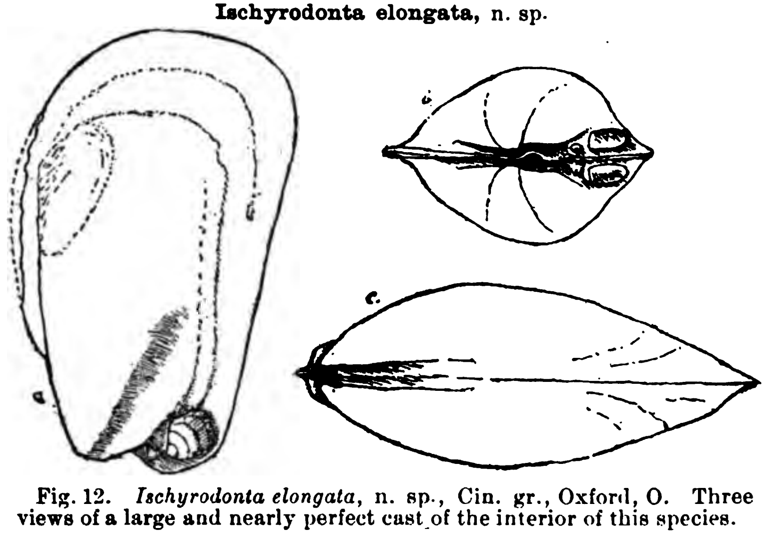

Fig. 12. *Ischyrodonta elongata*, n. sp., Cin. gr., Oxford, O. Three views of a large and nearly perfect cast of the interior of this species.

Of this species only casts of the interior have been seen. These may be described briefly as follows: Shell rather large transversely elongate-ovate, widest posteriorly, strongly convex, with point of greatest convexity a little in front of the

middle. Beaks prominent, compressed, almost terminal. Cardinal margin convex; posterior margin rather strongly convex, and generally somewhat straightened in the lower half; basal margin straight or faintly sinuate; anterior end abruptly rounded, very short. Anterior muscular scar deep, subquadrate, situated beneath the beaks. Just above it the small accessory scar.

The much greater length of this shell distinguishes it from *I. truncata*, with which it is associated. The outline is much like that of *Modiolopsis modiolaris* Conr., but the casts of that species are not so convex and the beaks less prominent.

Associated with this species and *I. truncata* I found several examples of a form apparently intermediate in character between the two. They are, unfortunately, not in very good condition, but as far as they admit of comparison it would appear that they represent nothing more than a slightly elongate variety of *I. truncata*.

Position and locality: near the top of the Cincinnati group, at Oxford, O., and Richmond, Ind.

Whitella, n. gen. (Ety., proper name.)

Shell large, thin, obliquely quadrangular or suboval equivalve, inequilateral, more or less ventricose, closed all around. Beaks prominent, incurved. Cardinal margin straight or slightly convex, the edges inflected to form a sharply defined escutcheon extending beyond the beaks nearly to the anterior extremity of the shell; area finely striated longitudinally. Hinge line straight, from one-half to two thirds the length of the shell, with four or five oblique teeth in front of the beaks. Posterior portion of hinge apparently edentulous. Ligament probably both external and internal,the latter only along the posterior third of the hinge line. Two simple adductor impressions, the posterior one very faint, pallial line simple, entire. Surface of shell with fine concentric lines and sometimes with stronger concentric undulations. Type, W. obliquata,n. sp.

The shells for whose reception this genus is proposed have been variously referred by authors to *Dolabra* McCoy, (by Meek and Worthen,) *Cypricardites* Conrad, (by Hall and Whitfield,) or *Cyrtodonta* Billings. If McCoy's description of his genus is reliable then *Whitella* is clearly distinct, since he

claims that *Dolabra* is founded upon inequivalve shells, having an edentulous hinge.

From *Cypricardites* (provisionally including *Cyrtodonta*) the new genus is totally different. All true species of that genus have thicker shells, a wide and strong hinge plate , and from two to four strong posterior lateral teeth. They have also no wide escutcheon as in *Whitella*, though a narrow striated ligamental area exists in some of the species.

The species which I would refer to this genus, besides those here described as new, are *Dolabra* (*Cypricardites*,) *sterlingensis* M. and W. (*Cypricardites quadrangularis* Whitfield, and (*Cyrtodonta hindi* Billings. At least four other undescribed species are known to me, two in the Trenton and Galena of Minnesota, one in the Trenton of Kentucky, and one in the upper beds of the Cincinnati group, at Waynesville, Ohio.

Whitella obliquata, n. sp.

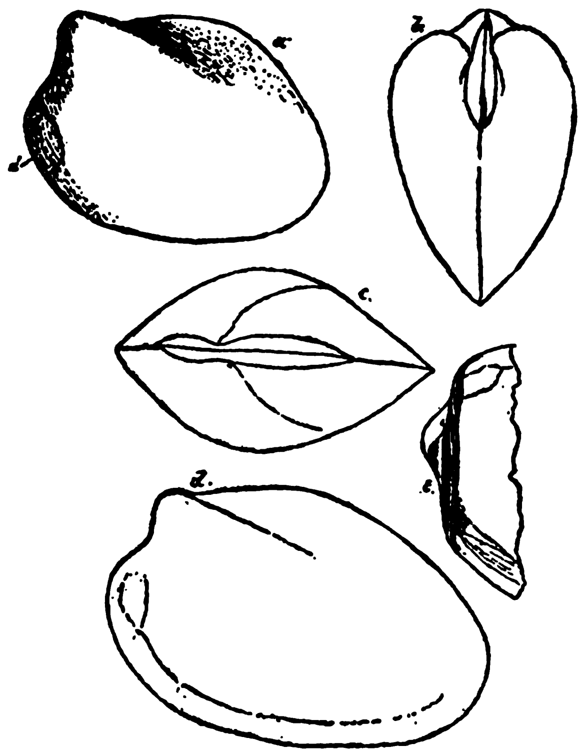

Fig. 13. *Whitella obliquata* n. sp. Cincinnati group, Blanchester, Middletown and Waynesville, Ohio, and Spring Valley, Minn., *a* left side of a cast of the interior, preserving a small fragment of the shell at "a"; the specimen is a small one but of the normal form, *b*, and *c*. anterior and cardinal views of another, nearly perfect, cast of the interior. *d*, left side of another cast, the hight of which has been a little reduced by compression. *e*, partial view of the interior of a valve from Minnesota, preserving the hinge teeth and faint muscular impressions.

Shell large, oblique, subrhomboidal in outline, produced in the postero basal region, ventricose, with point of greatest convexity above the middle; beaks rather small, prominent, slightly incurved, situated one fourth of the length of the hinge line from its interior extremity, umbonal ridge well marked, the cardinal slope concave. Anterior end small, narrowly rounded above, merging gradually into the evenly and only moderately convex ventral margin. Posterior end sharply curved and produced below, gently convex and sloping forward in the upper half to meet the slightly convex, cardinal margin. Escutcheon well marked, wide, shallowest in front of the beaks. Anterior muscular scar elongate. Hinge thin, the posterior half simple, the anterior half, of the left valve, with two long slightly oblique teeth just beneath the beak, and two shorter parallel ones at the anterior extremity.

The dimensions of cast of the interior, of the average size, are as follows: greatest length 50 mm.; greatest hight 38 mm.; greatest convexity 24 mm. A large specimen is 59 mm long, and 42 mm. high.

This species is related to *W. sterlingensis* (*Dolabra sterlingensis*, *M. and W.*) but has a longer hinge line, is less convex, wider posteriorly, and more oblique, the angle included between the hinge line and the umbonal ridge being much narrower. *W. hindi* (*Cyrtodonta hindi* Billings) is much more acutely produced posteriorly, being besides on the whole a more elongate shell, with the umbones also more tumid.

Position and locality: Upper beds of the Cincinnati group, at several localities in Ohio and Indiana. One specimen from an equivalent horizon at Spring Valley, Minn Though not a rare species, good specimens are not by any means common.

Whitella umbonata, n. sp.

A detailed description of this species is scarcely necessary, since the main point in identifying it is to distinguish it from *W. obliquata*. On comparison it will be found that the beaks and umbones are much larger than in that species, the pos-

tero-dorsal slope shorter and more abrupt, the hight comparatively greater and the outline in general somewhat different, particularly in the ventral region where the margin is more convex than in *W. obliquata*. *W. quadrangularis* (*Cypricardites quadrangularis* Whitfield) is much shorter and more erect.

In a large specimen the hight and length are respectively 47 mm. and 60 mm; in a small specimen 38 mm. and 45 mm. greatest convexity of the latter 25 mm.

Position and locality. Upper beds of the Cincinnati group at Blanchester, Middletown and other locations in Ohio and Indiana.

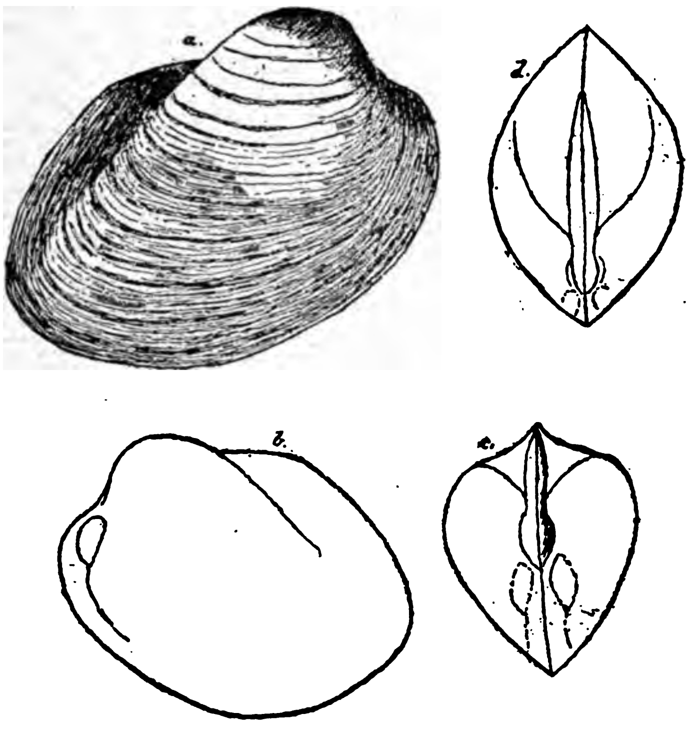

Fig. 14. *Whitella umbonata*, n. sp., upper beds of the Cincinnati group. *a*. View of the right side of a large example, taken from a gutta-percha cast of a natural mould of the exterior. *b*, *c*, and *d*, three views of a well preserved but small cast of the interior, collected at Middletown, Ohio.

Whitella compressa, n. sp.

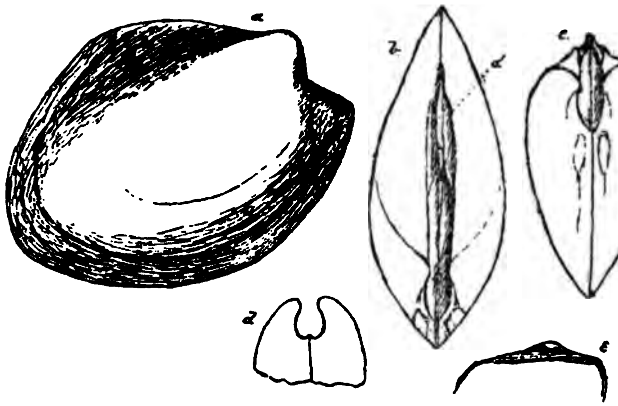

Fig. 15. *Whitella compressa* n. sp., Trenton shales, Minneapolis, Minn. *a*. right side of a cast of the interior; outline slightly restored. *b*, cardinal view of same, showing the impression of the internal ligament at "*a*"; *c*. anterior end view of same; *d*, outline view to show elevation of beaks above the hinge line. The figures are drawn to a scale a little less than natural size. *e*, view of the hinge of a specimen from the same beds at Cannon Falls, Minn., now regarded as belonging to another species for which the name *Whitella scofieldi* is proposed.[1]

This species resembles *W. obliquata*, from the upper beds of the Cincinnati group, rather closely, but differs in the following respects. It is much less ventricose, the umbonal ridge less marked, and the hinge line more extended anteriorly, causing the anterior end to be angular above or at any rate more sharply rounded than is the case in *W. obliquata*. None of the other species are very closely allied.

The best specimen seen I owe to the liberality of Prof. C. W. Hall of the Minnesota State University, who found it at Minneapolis, in the Trenton shales exposed in the railroad cut near the University. Its greatest length, measuring from the anterior extremity of the hinge line to the postero-basal angle, is 55 mm.; from beaks to same point, 51.5 mm.; from the posterior extremity of hinge line, at right angles with it, to basal margin, 41 mm.; greatest convexity 19.5 mm.

Fig. 15^e, is taken from an example collected at Cannon

[1]Since these descriptions and remarks were written I have received a lot of bivalve shells from Mr. W. H. Scofield of Cannon Falls, among them several specimens of *W. scofieldi*, showing it to be a good species. I hope to offer additional illustrations in the next number.

Falls, Minn., which preserves the shell. This I now regard as belonging to a distinct species with a more distinct umbonal ridge, greater tumidity and less projecting beaks, thus in almost every respect agreeing more nearly with *W. obliquata.* Still it must be regarded as specifically distinct from that species since there is a well marked difference in the dentition of the hinge, the teeth in front of the beaks being shorter and less nearly horizontal. Additional differences are brought out by a comparison with the Ohio specimens of that species, such as greater convexity, more pronounced umbonal ridge, slightly less projecting and more closely approximated beaks. The escutcheon also is narrower, with its sides more nearly vertical, while the internal ligament support at the posterior extremity of the hinge is stronger. The form of the shell is besides somewhat different, being comparatively higher and more erect.

The basal margin and lower portion of the posterior end are unfortunately broken away on the Cannon Falls specimen, but so far as the evidence at hand permits of judgment it would appear that the postero-ventral angle is more abrupt than in *W. obliquata.*

Taking all these points into consideration I feel justified in regarding it as sufficiently distinct to deserve recognition. I propose therefore to call it *Whitella scofieldi* in honor of Mr. W. H. Scofield of Cannon Falls, Minn., to whom I am indebted for many favors.

EDITORIAL COMMENT.

THE PRE-NATAL HISTORY OF THE GEOLOGICAL SOCIETY OF AMERICA.

The movement for the Geological Society was inaugurated at Cincinnati, Ohio, in 1881. The following are the official records:

The geologists of the American Association for the Advancement of Science, at the Cincinnati meeting, at a meeting held in the room of Section B, 5 p. m. Aug. 18, 1881, having resolved to organize an association of the geologists of America, appointed a committee to draft a constitution and organization of such society. This committee consisted of the following members:

George C. Swallow, Columbia, Mo.

N. H. Winchell, Minneapolis, Minn.
S. A. Miller, Cincinnati, Ohio.
Wm. J. Davis, Louisville, Ky.
John Collett, Indianapolis, Ind.
H. S. Williams, Ithaca, N. Y.

This committee met at the close of the meeting (of Section B.) with Prof. Winchell as chairman, and appointed H. S. Williams, Secretary, and after some consultation it was agreed that S. A. Miller be requested to draft a constitution for the consideration of the committee at its next meeting.

Adjourned.

The second meeting was held at 9 a. m. Friday, Aug. 19th. Present: Winchell, Miller, Davis, Williams and Swallow. Miller presented the following preamble and constitution:

WHEREAS, The geologists of America are without any central organization; there is no place for them to assemble for the discussion of difficult questions, and no publication which they can call their own; now, therefore, in order to bring them together in an association for the mutual benefit arising from such discussion and to found a publication devoted exclusively to their services, we do establish this society under the following constitution:

PROPOSED CONSTITUTION.

ART. 1. This society shall be known as the *American Geological Society.*

ART. 2. Any one desiring to cultivate a knowledge of geology or paleontology is eligible for membership. Members shall be elected by ballot at a regular meeting, except that during the interim members may be elected by the votes of the President, Treasurer and Secretary, in which case the Secretary shall record the ballot. The initiation fee shall be $10, and the annual dues shall be fixed by the by-laws; but any member contributing at any one time to the society the sum of $100 shall become a life member, free from the payment of annual dues or other assessment.

ART. 3. The officers shall be a President, two Vice Presidents, a Treasurer, a Secretary, and such other officers as may be required by the by-laws of the Society. They shall hold their offices for one year and until their successors are duly elected.

This constitution was discussed, amended, and was to be sent to other geologists for suggestions and improvements, but it was finally decided to be best to defer more definite action to the next meeting of the A. A. A. S., while a committee were to prepare a circular asking for the opinions of geologists generally, and reporting at Montreal. The Secretary, Prof. H. S. Williams, prepared a rough draft descriptive of the meeting and the contemplated action desired, which read as follows:

CIRCULAR LETTER TO THE GEOLOGISTS OF AMERICA.

At the Cincinnati meeting of the A. A. A. S. (August 1881) the geologists there present met together to consider the propriety of forming a separate organization promoting their mutual interests in directions not fully met by the A.A.A.S.

The demand for more uniform and united work by geologists throughout the country and for means of coöperation and intercommunication among such workers appeared to those present to offer good reason for the organization of an American Society of Geologists. This want is felt most by those engaged in the technical identification and description of fossils, and in the determination of the true values and relative position in the geological series of the rock masses appearing in the different parts of the country. For the purpose of mutual aid and cooperation in the furtherance of these ends, it was resolved by formal vote, as the sense of those present, that a distinct society of American geologists should be organized.

A committee was appointed to draft a constitution, but upon further consideration it was regarded as of great importance that all the geologists of the country (as far as possible) be consulted, and that permanent organization be deferred for more full and mature deliberation than could be taken during the present session of the Association. It was therefore proposed that a circular letter be prepared by the committee, conveying the sense of the geologists assembled, and that this be sent to all the geologists of America for their consideration and the time and place of the next meeting of the A.A.A.S. be designated for the final consideration and organization of such a society. The following are some wants which it is hoped may be attained by such an organization, and which are not provided for by any already existing society.

The want of greater uniformity in the methods of making and recording observations and in the usage of nomenclature; and a better understanding of each other's work over the vast territory of America.

The want of a common organ for the publication and discussion of geological matters, especially those relating to stratigraphy and paleontology.

The want of a central library in which shall be collected for reference and use a complete set of the publications needed by every working geologist, but many of which are at present out of print, very rare and almost impossible to be obtained or even consulted.

The desirability of the occasional meeting of American geologists for the purpose of coördinating and reducing to scientific system the great and rapidly accumulating mass of facts gathered by individuals or by state surveys in more or less restricted regions. The want of better facilities than at present exist of intercommunication among the numerous geologists in the country for their mutual aid and coöperation.

The geologists assembled at the meeting are of the opinion that those wants may be best supplied by the formation of a distinct society of

American geologists, with a permanent organization, a central and permanent abiding place, and an organ for the publication of the work of its members. These views are respectfully submitted to our fellow geologists of America with the request that they give them careful consideration, and that all interested in the accomplishment of the purposes here set forth may be present at the next meeting of the A.A.A.S. at Montreal, and prepared to take action in the matter—the organization of such a society as will meet the necessities and be worthy the grandeur of the work given to American geologists to accomplish.

The circular letter finally prepared by N. H. Winchell and adopted by the committee reads as follows:

CIRCULAR LETTER.

To the Geologists of America:

At a meeting of the geologists in attendance at the Cincinnati session (1881) of the American Association for the Advancement of Science, the undersigned were appointed a committee to correspond with American geologists, respecting the formation of a *American Geological Society*, the result of such correspondence to be reported at the next meeting of the American Association for the Advancement of Science.

Pursuant to such instructions, it is deemed best to present sundry considerations, some of them brought forward at Cincinnati, which seem to render it desirable that such a society be organized in America, and which have been approved, and hereby are presented jointly by the committee.

The committee are desirous of eliciting opinions from all active and professional geologists, to the end that more judicious and effective action may be taken at the next meeting.

1. The science of geology, with its kindred branches of palæontology and lithology, has made rapid progress in America—perhaps more rapid than in any other country—in the last twenty years.

2. The literature of geology is largely distributed through numerous scientific journals, and in the proceedings of miscellaneous scientific societies, to procure which is difficult and expensive.

3. The present facilities afforded through the American Association for the Advancement of Science are insufficient, and are unavailable by the working geologists of the country—because: (a.) The meetings are held in the summer, which is the geologist's working season. In order to be present he must interrupt his work and leave the field, often at considerable expense especially if he has a party with him. (b.) Its brief meetings partake largely of the nature of vacation pleasure-parties, and much of the time is engrossed by reception, gratulation and excursions. (c.) There is no sufficient avenue of publication of the work of geologists and especially of palæontologists. (d.) The association has become so large, wide-spread and popular in

its work, membership and organization that its spirit necessarily, and properly, is not favorable to the development of any special work through its own agency.

4. The geologists as a body, have no way of expressing their views on important state, national or international measures, except through the medium of the American Association, at the meetings of which there is a perceptible and increasing lack of attendance and interest on the part of geologists, in consequence of which the actual views of the geologists of the country on such questions can not be obtained and expressed correctly.

5. There is a need of co-ordination of the results of state surveys, to the establishment of greater uniformity in nomenclature and classification.

6. There is a need of co-operation on the part of palæontologists, and of some system in describing and publishing new species.

7. There is no strictly geological magazine or journal in America.

8. There is no strictly geological society in America.

9. There are numerous such societies and journals in Europe, as well as journals and societies devoted exclusively to the branches of palæontology and mineralogy.

The committee desires also to disclaim any intention to trespass on the field and plans of the American Association for the Advancement of Science, or to criticise it in any way as to the discharge of its functions. Its tendency is to popularize science and to advance its acceptance by the world by diffusing scientific knowledge, and by announcing important discoveries, and as such its sphere of activity is one that no special scientific body can occupy, but which still will be aided by the existence of tributary organizations, such as that contemplated by this circular.

Persons to whom this circular is addressed are requested to communicate promptly their views and recommendations to any member of the committee, in order that a report may be presented at the Montreal meeting of the American Association, embodying such recommendations as may be warranted by the correspondence, and summarizing the same.

Signed: N. H. WINCHELL, State Geologist of Minnesota,
Minneapolis, Minn.
JOHN R. PROCTER, State Geologist of Kentucky,
Frankfort, Ky.
HENRY S. WILLIAMS, Professor of Palæontology,
Cornell University, Ithaca, N. Y.
JOHN COLLETT, State Geologist of Indiana,
Indianapolis, Indiana.
G. C. SWALLOW, Professor of Geology, etc.,
University of Missouri, Columbia, Mo.
WM. J. DAVIS, Palæontologist,
Assistant Geol. Sur. of Ky., Louisville, Ky.
S. A. MILLER, Palæontologist,
Cincinnati, Ohio.

Prof. H. S. Williams presented notes and suggestions at Montreal, in 1882, derived from the replies made to the circular sent out by the committee. Most of these are quoted below. Those omitted are of persons who did not finally become fellows of the existing G.S.A.

S. A. Miller, Cincinnati: Approves "if such a society can be formed without unwarranted contention."

R. Ellsworth Call, Des Moines, Ia.: "The project meets my hearty approval." Urges that it should include only "working geologists." "The project is well devised." Very cordial in approval. A strictly *geological journal* could be successfully sustained.

Jas. Macfarlane, Tonawanda, Pa.: "Most heartily concurs with every word" of the circular, and "sincerely hopes" the society may be formed.

Warren Upham, Minneapolis: Receives his hearty approval. "Such a society can be abundantly supported" and "made an efficient working organization" and "will contribute to a more rapid and more sure extension of our knowledge in geology."

Franklin and *W. G. Platt*, Philadelphia: Entirely agree with the Committee, and will cooperate in carrying out the scheme and the establishment of a geological magazine in any way that may be chosen.

W. P. Blake, New Haven, Ct.: Pledges his hearty cooperation in any well considered plan.

C. A. Ashburner, Philadelphia: After much consideration comes to the following conclusions: 1. The movement should be general and issue with the approval of representative geologists. 2. There should be numerous sub-societies whose membership shall cover special areas with close fellowship and correspondence. 3. Very great need of a geological magazine. 4. There should be a league or congress to meet in different parts of the states every four or five years, the members being only members of local societies authorized by the congress. The journal shall be published by a committee nominated by the several societies and elected by the league. Every society should publish its own transactions, and the league a brief of its proceedings.

J. D. Dana, (in a letter to Ashburner, dated August 25, 1887): "There is no doubt that a geological journal would be a good thing for the science if it would be used by authors. The country is so large that every little corner has its publishing society, and so science is as wide spread in its original publications. There is good in this but great inconvenience—and evil also."

R. T. Cross, Denver, Col.: "There certainly ought to be an American Geological Society."

P. A. Chadbourne, Amherst, Mass.: "The reasons given in the circular letter for forming an American Geological Society are weighty, and I shall be glad to cooperate in forming such a society."

G. K. Warren, Newport, R. I.: "I heartly endorse the movement."

J. E. Todd, Beloit, Wis.: "I say to you, as a member of that committee, *Amen.*"

A. Winchell, Ann Arbor, Mich.: "Circular letter was received with great satisfaction. The considerations presented seem to me pertinent and weighty. I promise it my full sympathy and support; and hope a large proportion of the representative geologists of America will return a hearty response to the project."

E. W. Claypole, New Bloomfield, Pa.: "I should be very glad to see such a society established in this country, and to do all I can to aid it. Nor do I think it impossible, though difficult to maintain such a society in an active and efficient condition." Endorses all the points in detail, and then considers whether such a society, if established, is likely to last and be successful. This depends mostly on the foundation and methods adopted. He does not think fortnightly nor monthly meetings could be sustained. England is so small that the geologists can attend such meetings. In the United States the distances are too great for members to meet often. If the meetings are to be held in connection with the A.A.A.S. there would be unpleasant rivalry. He concludes there should be *no meetings* but the *reliance shall be on publications alone* as the bond of union.

Robert Bell, Ottawa, Canada: Expresses hearty approval of the proposed Geological Society. Its desirability is so well set forth in the circular that it would be difficult to say more in favor of the plan. "I endorse every one of the reasons therein stated" etc., and "trust that my name will be put down as one of the original members" at the approaching meeting in Montreal.

Wm. M. Davis,Cambridge, Mass.: "I shall be very glad to aid the promotion of an American Geological Society in every way in my power—especially if it should undertake the publication of an authoritative journal in which besides original articles one could find abstracts of or references to everything of importance published in this country or in Europe connected with the subject. I think such a society, with its meetings and branch meetings (if necessary) and publications, would at once take good rank among the scientific societies in the country, and would have efficient support from geologists and paleontologists."

P. W. Schaeffer, Pottsville, Pa.: Heartly approves the suggestions of the circular, but queries whether there should not be head-quarters somewhere—perhaps in New York, with office, library and museum, with meetings sometimes there and sometimes at other points.

M. C. Read, Hudson, O.: "The formation of such a society would be of great advantage to American geology, especially if it leads to the establishment of a well-edited geological journal, as it would do much to secure a reliable and common nomenclature by American geologists."

S. E. Tillman, West Point, N. Y.: "Such a society, it seems to me, is very desirable and almost necessary; and I shall be most happy to aid in its establishment in every way in my power."

Chas. E. Billin, Ill.: "The geological society should stand on its own feet, and not start as a section of any other society. You can count on me as a supporter."

O. E. Ulrich, Cincinnati, O.: "I heartily endorse the committee's circular."

W. H. Pettee, Ann Arbor, Mich.: "In the circular letter the reasons why it is desirable to form a new society, in addition to those already existing, are stated quite cogently; and I am now more strongly inclined than I have hitherto been, to favor the project."

C. H. Hitchcock, Hanover, N. H.: "The proposal strikes me favorably. It is not necessary to be divorced from the parent association, any more than for the chemical and entomological societies, which frequently hold sessions in connection with those of the A. A. A. S. It would not be desirable to conflict with that. It might be practicable to meet sometimes with the mining engineers. If the membership shall include all geologists, it would be practicable to combine their energies to secure certain objects not now attainable. We could organize committees to propose a scheme for classification of rocks or uniform colors, unless we accept the results of the International Congress. We could catalogue the fossils, make a U. S. map, etc. Better than all, we could establish a magazine in which every one could be free to express his opinions. We shall have to organize on a free, democratic basis. There should be no cliques to unite. The free voice of the majority should decide every disputed point. Votes upon debated points should be obtained by correspondence. If enough geologists would cooperate to make the society a success, I should be in favor of trying."

G. H. Stone, Colorado Springs, Col.: "I am in favor of such a society, provided it can be made to remedy the defects of the A. A. A. S. To this end it would be necessary to secure the very general coöperation of geologists and also large endowments so as to publish the parers presented. If geologists have to furnish their own plates (as in A. A. A. S.) no gain will be secured. If an efficient plan is adopted I shall be glad to aid it in any way in my power."

Edward Orton, Cleveland, O.: "I am cordially in favor of an association of American geologists under proper auspices. The new organization need not come into collision or rivalry with the A. A. A. S."

John Collett, Indianapolis, Ind.: "The desire for such a society is unanimous and emphatic."

W. J. Davis, President of the Ohio Falls Geological Society, Ky., regrets being unable to attend the Montreal meeting, and authorizes N. H. Winchell to act as his proxy. The Geological Society of thirteen members approves of the formation of this national or rather *American* Geological Society, so as to include the Canadian brethren.

Principal J. W. Dawson, McGill College, Montreal, P. Q., in acknowledging the receipt of circular, says: "In this matter we have been beforehand with you in Canada. Our new Royal Society has a geological section which will serve all the purpose to us of a Geological

Society." "We shall probably, therefore, constitute a distinct body from that which you may form in the U. S., but shall be very glad to keep up friendly intercourse and coöperation."

Report of the Proceedings at Montreal, 1882 (official). At the Montreal meeting of the A. A. A. S., August. 1882, a number of American geologists convened to consider the question of organizing an American Geological Society; Prof. A. Winchell was chosen chairman and C. H. Hitchcock secretary. Several sessions were held, whose proceedings may be summed up in the following statements:

Prof. N. H. Winchell, chairman of the committee appointed in Cincinnati in 1881, to correspond with geologists upon the expediency of forming such a society, reported that ninety answers had been received in response to his circulars, all but two of which spoke favorably of the project. Prof. H. S. Williams, Secy., reported answers from thirty persons; and S. A. Miller reported answers from six persons, all favorable: making a total of one hundred and twenty-six opinions in favor of, and only two dissenting from the formation of the proposed society.

A committee consisting of Jed Hotchkiss, R. P. Whitfield, and C. H. Hitchcock was appointed to consider the situation, and report the most suitable action to be followed. This committee recommended as the first step to be taken, the establishment of a geological magazine. This report was accepted and adopted. The Cincinnati committee reported a constitution for the formation of a geological association, which was discussed and laid upon the table; and the committee desired to continue their labors and report at Minneapolis in 1883.

Last of all, a committee consisting of C. H. Hitchcock, J. S. Newbury, N. H. Winchell, H. S. Williams and G. H. Cook was designated to confer with Major J. W. Powell of Washington, with the view of ascertaining what encouragement could be afforded by him in the support of the proposed geological magazine.

On motion of James Hall it was voted to recommend to Section E (A. A. A. S), the appointment of a committee to confer with the director of the U. S. geological survey in regard to coöperation between the national and state surveys.

The persons present at these several meetings were Profs. A. Winchell, N. H. Winchell, E. T. Cox, H. S. Williams, W. H. Niles, E Orton, E. T. Nelson, Jed Hotchkiss, R. P. Whitfield, A. H. Worthen I. C. White, E. W. Claypole, G. H. Cook, J. W. Spencer, J. S. Newberry, James Hall, T. Sterry Hunt, H. F. Walling, E. D. Cope and C. H. Hitchcock.

C. H. Hitchcock, Secy.

The committee mentioned above conferred with major Powell in regard to the magazine. He expressed a desire for the success of the magazine, and a readiness to contribute to its welfare when established; but thought it would be prejudicial to its interests if he were identified with its inception.

C. H. Hitchcock, Secy.

PROPOSED CONSTITUTION.

This society shall be called "The American Geological Society." Its object shall be the extension of the science of geology in America by the following means:

(*a*) The publication of a geological magazine or journal.

(*b*) The publication of memoirs on any branch of the science in such manner as hereinafter provided.

(*c*) The maintenance of an organization for the discussion of general questions of importance in cartography, nomenclature and stratigraphy.

(*d*) The assembling of the geologists of the country for mutual information and comparison of their respective work.

Any person may become a member of this society by subscribing to the constitution and paying the initiation fee of five dollars, and may maintain such membership by the annual payment of the sum of three dollars. Any member in arrears two years shall be stricken from the roll providing he shall have been twice notified by the secretary of the society after an interval of six months.

Executive Council. There shall be elected by printed ballot from the members of the society after open nomination an *Executive Council* numbering twenty-five, whose duties shall be such as hereinafter provided. Those members only shall be eligible to the Council who shall have prosecuted within the last preceeding five years, some original work in geology or shall have published such original papers as shall show that they are actively engaged in the science.

Duties of the Council. The executive council shall have charge of all the work and property of the society. The executive council shall be elected in the first instance by those geologists present at the first meeting after the adoption of this constitution, and annually thereafter three new members shall be elected at large by the society. The council first elected shall be divided into five sections in alphabetical order for the purpose of determining the tenure of office of each member. These sections sh l determine by lot which shall hold office for one, two and three years respectively, and at each annual election those newly elected shall fill the places of those whose terms shall annually expire.

The executive council shall determine the number and material of all publications, and shall have the responsible control of all its work and property, except so far as otherwise determined by this constitution. They shall take measures to extend the membership of the society, to establish and maintain a geological magazine when in their judgment such journal would be successfully maintained; to publish the works of paleontologists and others, in memoirs or in serials; to call meetings of the general society at such times and places as they shall determine and shall arrange for the programs of proceedings at such meetings, and do such other things as shall be in their judgment necessary for

the prosperity of the society and the promotion of geology in America.

Officers. The officers of the society shall be a president, who shall be elected annually by the society at large, and shall be the president of the executive council and a member thereof by virtue of this office; a secretary, who shall be elected by the council, who shall perform such duties as the council shall prescribe, and receive such compensation as the council shall determine; and a treasurer.

Minutes of the Minneapolis meeting. (Official.) At the Minneapolis meeting of the A. A. A. S., the adjourned session of the geologists assembled to consult about the geological society and magazine was held Aug. 21, 1883. The records of the Montreal meeting were read and approved. Prof. N. H. Winchell was elected chairman.

A letter was read from the Mineralogical and Geological Section of the Philadelphia Academy of Natural Sciences, addressed to the President of Section E favoring the formation of an American Society of Geologists "provided that such action shall be generally concurred in by American geologists,and that its permanency and a liberal publication of professional papers be insured by an ample endowment fund." [Signed] Chas. A. Ashburner, Secretary.

After much and varied discussion it was *Resolved* that a committee be appointed to confer with the Mineralogical and Geological Section of the Philadelphia Academy of Natural Sciences with reference to the formation of an American Society and the establishment of a geological magazine.

The president and secretary of section E at the Philadelphia meeting A.A.A. S. were designated as a part of this committee, the others being selected by Prof. N. H. Winchell, the chairman of this meeting. As finally constituted, this committee consisted of Profs. N. H. Winchell, E. A. Smith, C. A. White, C. H. Hitchcock, H. S. Williams.

The geologists present at the Minneapolis conference were N. H. Winchell, J. S. Newberry, T. S. Hunt, E. Orton, J. W. Spencer, E. T. Cox, J. W. Powell, W. Upham, J. P. Lesley, E. W. Claypole and C. H. Hitchcock. C. H. Hitchcock, Secretary.

The friends of the new movement became very much discouraged by the expression of unfavorable views at Minneapolis; and the report of these opinions seemed to have reached the members of the Philadelphia Academy, since they made no effort to consult with the members of the committee at the Philadelphia meeting of the A. A. A. S. in 1884. Four years later various causes led some of these opponents to change their minds, and the chairman and secretary of the moribund organization saw that nothing would be done by other parties, and so in virtue of their office they sent out a call to their confrères to meet at Cleveland, Ohio, in connec-

tion with the 1888 session of the A. A. A. S. This final appeal proved to be efficacious as it led to the organization of the Geological Society of America.

Meanwhile, several of the geologists, unwilling to delay longer the issuance of a geological magazine, boldly took the initiative and established THE AMERICAN GEOLOGIST, a monthly journal of geology. The first number appeared January, 1888, with the following gentlemen for editors and proprietors: Prof. S. Calvin, Prof. E. W. Claypole, Dr. Persifor Fraser, Dr. Lewis E. Hicks, E. O. Ulrich, Dr. A. Winchell and Prof. N. H. Winchell. The call for the Cleveland meeting appeared in the GEOLOGIST for June, 1888, (which see).

Selections from answers to this circular:—

W. B. Potter, Washington University, St. Louis, Mo.: "I should like to see a geological society formed on an independent basis similar to that of the Geological Society of Great Britain, holding three or four meetings a year and having the direction and control of a geological quarterly magazine, in which high class papers on geológical subjects should appear, with reliable notes, references and reviews of geological material. It does not seem to me that this is too much to expect of the present stage of geological knowledge and interest in this country."

A. R. C. Selwyn, Director of the Geological Survey of Canada. "I cordially endorse the idea [of the society], and have no doubt many of our geologists will join the society when inaugurated."

F. W. Putnam, Permanent Secretary, A.A.A.S.: "As to the extra meetings of Section E, I do not see any reason why Section E cannot vote to meet at such times as it may agree upon, and simply request the sanction of the council. If the council agrees to a plan carefully matured by the section, I should think that would settle the matter. Of course the section could not involve the Association in any expense not previously sanctioned by the council, and any matter of publication would have to be acted upon by the council."

E. D. Cope, Philadelphia: "On general principles I object to any more societies and publications than we have. But the only desideratum is closely defined membership, so that such new societies shall be an *improvement* on what we have. If the membership be so restricted would there be enough members to pay expenses? I incline to think that there would be enough working geologists in the country to carry on such a society sucessfully; but I suspect that the existing bodies would suffer by their frequent absence. On the whole I am in favor of such a society, *provided*, (1) that its membership is limited to geologists who have actually done good work, and (2) that it have its own officers independent of all other bodies whatsoever. But such a society must look to the future for its principal utility.

J. J. Stevenson, New York City, does not wish the new society to be

merely synonymous with section E. "I should prefer much to see an American Geological Society to which none might be eligible except those who have made contributions toward the advancement of American geology."

J. C. Smock, Albany, New York, favors the formation of a club or society identical with section E, and not a new distinct organization. "I would suggest a meeting in the early summer or in May, and to have for its object excursions to interesting localities."

W. H. Pettee, Ann Arbor, Mich. "I was not in favor of the independent organization proposed at first, principally for the reason that it seemed likely to antagonize the general society. To the present proposition I can give a most cordial assent."

J. C. Branner, State Geologist of Arkansas: "Hastens to say that the formation of such an association seems to me most desirable, as is also the method suggested."

H. S. Williams, Ithaca, N. Y.: "I would like to see a live American Geological Society; but I have serious doubts of the possibility of turning section E into such a society."

L. E. Hicks, Lincoln Nebraska, is "in favor of the proposed organization of an American Geological Society."

John Collett, Indianapolis, Ind., is opposed to each of the propositions relative to a connection with the A. A. A. S.

W. J. McGee, of U. S. Geological Survey, doubts the expediency of organizing a geological society in connection with the A. A. A. S. "I am in favor of the organization of an American Geological Society as soon as we can feel assured of its success. I will join, contribute freely towards, and work energetically for an American Geological Society, provided it is so constituted as to secure the support of two-thirds or more of American geologists; and though I should prefer that the society were independent of the A.A.A.S., I will not make my support contingent upon that condition."

H. L. Fairchild, Secretary New York Academy of Sciences, approves of the plan of the circular. "I doubt if a distinct geological society is worth as much, all around, as section E of the A.A.A.S. But an independent "American Geological Society," *being* section E has the advantage of both. It meets my ideas exactly."

Persifor Frazer of Philadelphia strongly opposes the proposition to make the proposed society coextensive with Section E.

T. Sterry Hunt of Montreal, would keep the two associations distinct. Hopes the management of the society will not fall into the hands of any clique or party.

E. A. Smith, Tuscaloosa, Ala., approved of the plan of the circular.

G. C. Broadhead of Missouri, thinks that geology does not of late years maintain its proper prominence in the A. A. A. S. and wishes success to those who are trying to inaugurate a new association.

J. D. Dana of New Haven, Conn., thinks the proposed society "would be a good thing and tend to promote good feeling among geologists, as well as good science. Only I would not have membership

dependent upon membership in the national association, but instead throw open the doors widely to all true geologists that care to come."

W. M. Davis of Cambridge, Mass., asks if the proposed society would not interfere with the winter meetings of the Society of American Naturalists. Suggests that with membership as open as that of A. A. A. S. the society would not be an advanced institution. He would have stricter attention paid to technical geological business at the meetings of Section E, etc.

C. H. Hitchcock, Hanover, N. H., suggests (1) that members of Section E, F and H of A. A. A. S. be eligible to fellowship in the new organization; (2) officers of Section E to be *ex officio* the managers of any extra meetings through the year; (3) sectional committee of Section E with the President and Secretary to constitute the council for the management of the the society; (4) the council to call the extra meetings and to make all the necessary arrangements; (5) excursions for the purpose of acquiring familiarity with noted localities to be a specialty; (6) special publications to be issued whenever there are funds on hand sufficient for that purpose; these to be issued in slips or forms and distributed to every member as soon as printed.

A sketch of the meetings held later, leading to the establishment of the present Society, will be found in volume 1 of the *Bulletin.*

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Characteristics of Volcanoes, with contributions of facts and principles from the Hawaiian islands, including a historical review of Hawaiian volcanic action of the past sixty-seven years, a discussion of the relation of volcanic islands to deep sea topography, and a chapter on volcanic island denudation. By *James D. Dana.* Illustrated by maps of the islands; a bathymetric map of the Atlantic and Pacific oceans; and views of cones, craters, a lava cascade, a lava fountain, etc. New York: Dodd, Mead & Co., 1890. 8 vo. pp. xvi, 399, with 16 plates and 55 illustrations in the text.

The title-page of this volume well indicates its scope and contents. Excepting its first 24 pages, which are an elementary general description of volcanoes and their products, with remarks on the methods and causes of volcanic action, it is chiefly reprinted from articles published in the American Journal of Science during the past four years. The author's first observations on the Hawaiian volcanoes were made in 1840, as geologist of the Wilkes United States Exploring Expedition; and in the preparation of this work he again visited these islands in 1887, fifty-three years after the beginning of his study of the volcanoes in an ascent of Vesuvius. His son, Prof. Edward S. Dana, contributes 37 pages on the petrography of the Hawaiian lavas, of which 10 pages with a plate and several figures describe very remarkable lava stalactites from caverns in the Mount Loa lava streams.

In accordance with the author's theory, now generally accepted, that the great oceanic depressions and continental plateaus became distinct features of the earth in the Archæan era and have since been permanent with only minor oscillations, we must refer the great volcanic range of the Hawaiian or Sandwich islands, as likewise other islands rising from abyssal oceanic depths, nearly all of which consist entirely of igneous rocks, to the eruption of molten portions of the primal earth crust, for no stratified deposits of considerable thickness could be formed so far from the borders of the continents. The lavas of the Hawaiian islands are augitic basalts,varying chiefly in the amount of chrysolite present. Molecular permeation of the magma in the volcanic conduits by water as superheated steam, producing vesiculation and in its escape throwing up jets of lava six to nine hundred feet high in the crater of Mount Loa, is attributed to infiltration of the water of rains and its slow absorption by the column of molten rock. This seems to be demonstrated by the more frequent occurences of eruptions in the rainy season, and by the greater volumes of steam and consequently higher lava jets in the summit crater than in Kilauea, 9,000 feet lower and twenty miles distant on the flank of Mount Loa. Furthermore, the independent and unsympathetic action of these vents upon the same mountain mass shows that the elastic vapor of water which uplifts their lava columns is accessory and of superficial origin, instead of being an original constituent of the magma at the great depth whence the conduits derive their supplies of lava and of volcanic heat.

This valuable treatise, and that of Capt. C. E. Dutton in the Fourth annual report of the U. S. Geological Survey, with the earlier notices reviewed by professor Dana,give to the Hawaiian islands the foremost place in the literature of vulcanology, a most important branch of geologic science still presenting many questions to be solved.

The Geographic Development of Northern New Jersey. By WILLIAM MORRIS DAVIS and J. WALTER WOOD, Jr. (From Proceedings of the Boston Society of Natural History, vol. xxiv, 1889, pp. 365-423; with 16 figures of maps and sections in the text.) This essay is based on field work by the authors as teacher and student at Harvard college, with the aids of the reports and admirable contoured maps published by the State Geological Survey. The investigation proved very instructive, and its methods and general conclusions will probably be found to have a wide application to other portions of the Atlantic slope when simularly accurate topographic maps of adjoining states and the eastern provinces of Canada shall be made.

The Appalachian revolution, culminating in Permian time, produced mountain ranges strongly folded and presumably of great hight for a certain period; but in the area of the Triassic belt their topography seems to have been reduced to a moderate relief before Triassic deposition began. During an ensuing epoch of mountain-building the great mass of sediments accumulated in the Triassic cycle suffered

monoclinal tilting and faulting, with the result of a new mountainous topography of less elevation and much less structural distortion than that of Permian time. The Appalachian mountains are therefore not to be regarded as the residual relief of an elevation given once for all at the time of the great Permian folding. The original mountain ranges were worn down low before and during Triassic time, after which, in the Jurassic period, they were again uplifted and much eroded to a surface named by the authors the Schooley peneplain. Next the southeastern portion of this area was moderately depressed beneath the sea and covered by Cretaceous sediments. The ridges of the present time, showing remarkable evenness in their general hight are parts of the old peneplain that have as yet withstood the erosion consequent on a third uplift, which as well as other oscillations of later date, seems to have been of moderate amount and gentle inequality.

Very interesting studies of changes in the course of streams are given in detail with numerous maps. The valleys in the Archæan highland portion of the peneplain are mainly coincident in position with those of an earlier geographic cycle, but in the Triassic area most of the streams were superimposed upon the present rocks from Cretaceous strata that formerly stretched across them, and in many instances they appear to have been much affected by adjustments required by their denudation of the soft Cretaceous formation and the uncovering of the hard trap ridges of the Watchung mountains.

Geology of the Lassen Peak District. By J. S. DILLER. Pages 395-432; plates XLV-LI; figures 13-19. (Accompanying the eighth annual report of the director of the U. S. Geological survey.) The mountain district of northern California here described, culminating in Lassen peak, 10,437 feet above the sea, appears topographically to be a continuation of the Sierra Nevada, but is found to belong geologically to the Cascade range. Eruptive rocks of the Pliocene and Quaternary periods, including rhyolite, quartz andesite (dacite), hornblende andesite, hypersthene andesite, basalt, and quartz basalt make up the entire Lassen ridge. These overlie sedimentary rocks, which in descending order comprise Pliocene and Miocene strata, the Chico beds of the upper Cretaceous, and the auriferous slate series. The present report treats mainly of the sedimentary formations and the topographic changes brought about by erosion and deposition, by the outpouring of lava, and by orographic movements; while detailed descriptions of the igneous rocks are reserved to a later report.

After the folding and uplifting of the auriferous series near the close of the Jurassic period, Mr. Diller finds evidence that "during the whole of the Cretaceous and the Tertiary the great belt of country lying east of the present Sacramento valley, embracing the region now occupied by the Sierra and a large portion of the Great Basin, was above the sea, and subjected to great degradation, which reduced it almost to its base level of erosion." But at the end of the Pliocene period this area is shown to have been greatly elevated by successive uplifts

accompanied by volcanic outbursts along the course of the Sierra and Cascade ranges. Still later, during the Quaternary period, profound faulting has separated the high Sierra as a distinct range by the subsidence of the Great Basin region.

The author thus refers the upheaval of this highest mountain range of the United States and the immense lava flows of the Pacific slope to the same period during which ice was accumulated in vast thickness and weight on the northern half of the continent. The possible and indeed the probable causal connection of these great geologic developments has been pointed out by Prof. A. Winchell in the first volume of the AMERICAN GEOLOGIST. With the more extended exploration of the geology of the Sierra Nevada, now being prosecuted by Mr. Becker of the U. S. geological survey, we may hope for much fuller knowledge of its age and history; and at the same time Capt. Dutton's researches on the great volcanic areas stretching thence northward may be expected to afford means for close correlation with the drift formations and the continental ice-sheets.

The Fossil Butterflies of Florissant. By SAMUEL H. SCUDDER. Pages 433-474; plates LII and LIII; figures 20-22. (Accompanying the eighth annual report, U. S. geological survey.) Seven of the total seventeen known species of fossil butterflies have been found at Florissant, Colorado, as described in this memoir, in beds supposed to be of Oligocene age. Their general aspect is regarded as distinctly subtropical and American; but one species, belonging to the aberrant group Libytheinæ, is "specially curious, as it resembles least of all the American species of the sub-family, and most of all one that occurs in western Africa." From characters observed in the structure of the Florissant butterflies, Mr. Scudder infers that there was very rapid development when butterflies first appeared, or that they began to exist at a far earlier period than the Oligocene, in which, at Aix, the oldest fossil butterflies of Europe have also been obtained.

The Geology of the Island of Mount Desert, Maine. By NATHANIEL SOUTHGATE SHALER. Pages 987-1061; plates LXIV-LXXVI; figures 231-45. (Accompanying the eighth annual report, U. S. geological survey.) The examination of Mount Desert was undertaken for the purpose of determining to what extent this part of New England has been affected by changes of level since it was uncovered by the recession of the ice-sheet at the end of the glacial period. Mount Desert, the largest island of the rocky, fiord-indented coast of Maine, having an area of about a hundred square miles, was selected for this inquiry because it is the highest part of the whole eastern shore line of the United States. Green mountain, the culminating point, rises 1,527 feet above the sea, and the average elevation of the island is almost five hundred feet. Its cliffs of rock, mostly facing the south and east, and its long, smooth northwardly descending slopes of till, are well adapted for preserving evidences of former submergence of the land.

Professor Shaler believes that he finds one class of shore lines, namely, rock escarpments eroded by wave action, clearly traceable in certain localities at successive hights, first, 90 to 100 feet above the sea; second, about 160 to 195 feet; third, about 220 to 240 feet; fourth, from 270 to 290 feet; fifth, about 300 feet; sixth, 380 to 430 feet; and seventh, about 480 to 500 feet. At still greater heights precipitous cliffs, which Prof. Shaler thinks to have been worn by the sea, occur in numerous places between 550 and 1000 feet above the sea. Finally, on the more gently sloping mountain summits of the island, eroded benches of rock are found at the hights of 1,140 to 1,160 feet; 1,210 to 1,240 feet; and, less distinctly, from 1,280 to 1,320 feet, at 1,460 to 1,480 feet, and at about 1,510 feet, or only 17 feet below the top of the Green mountain. The author therefore concludes that the Mount Desert region at the time of the disappearance of the ice-sheet was depressed probably not less than 1,500 feet, and certainly more than 1,200 feet, below its present level, to which he supposes that it has been elevated by a succession of uplifts, sometimes very sudden, with long intervening stages of repose.

It seems more probable, however, if not altogether sure, that the eroded rock benches and cliffs so fully observed and described in this memoir have been produced by the ordinary process of subaërial denudation, in which the formation of horizontal benches, resembling those of shore lines, would result from the presence of the nearly horizontal system of joint planes intersecting the granites of these mountain slopes. Indeed, this explanation of the origin of the rock scarps without aid from marine action is the only view consistent with the absence of wave-cut terraces and wave-built beach ridges upon the deposits of glacial drift which cover large tracts of the island. Nearly twenty years ago Prof. Shaler thoroughly searched for shore lines of this class on Mount Desert, but found no traces of them (Memoirs, Boston Society of Natural History, 1874, vol. II. p. 327); nor have any been discovered during more recent investigation. This deficiency, though not alluded to in the present report, seems fatal to its argument that there has been a great and long continued postglacial submergence.

But marine fossils occurring up to the hight of about 100 feet above the sea in the stratified beds on Mount Desert formed during the glacial retreat, and at the hight of about 200 feet on Deer Isle, ten to fifteen miles distant to the southwest, show that the region was depressed to a moderate amount. From the elevations at which such fossiliferous marine deposits are found overlying the till, it is known that the postglacial submergence of the land, beginning in the vicinity of Boston and in Nova Scotia, gradually increased toward the north and northwest to about 520 feet at Montreal. This depression, however, appears to have been of short duration, for no definite lines of shore erosion or beach deposits raised above the present sea level have been discovered, if we except these rock benches and cliffs of Mount Desert.

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THE THICKNESS OF THE DEVONIAN AND SILURIAN ROCKS OF WESTERN CENTRAL NEW YORK.

CHARLES S. PROSSER.

The Pioneer well of Findlay, Ohio, demonstrated in November, 1884, the existence of natural gas in commercial quantity in the Trenton limestone of northwestern Ohio. The discovery of a new geological horizon for oil and gas was followed by the drilling of test wells in other states, especially in those which were partly underlain by the Trenton limestone, and the attention of prospectors was early directed toward New York state as a promising field. In April, 1887, a test well was commenced in central New York, near Morrisville, Madison county.[1]

During the remainder of the year wells were drilled in western central New York at Ithaca, Seneca Falls, Clyde, Wolcott, and Fulton. In the Seneca Falls, Wolcott, and Fulton wells a small quantity of natural gas was obtained; but, not in sufficient amount for commercial purposes. The gas in the Seneca Falls well came from the upper part of the Medina sandstone and from the upper Trenton limestone in the Wolcott and Fulton wells.

Although the wells have been failures, in so far as obtaining natural gas for commercial purposes is concerned; yet, from a

[1]A geological description and section of the Morrisville well are given in Proc. A. A. A. S. vol. XXXVI (1888), pp.208, 209.

scientific standpoint, they have furnished the geologist with mportant information. Previous to the drilling of these wells it was not possible to give accurately the thickness of the Devonian and Silurian rocks of central New York. The thickness of the formations was estimated in various ways, principally by the following two: first, from sections of cliffs or hills and secondly from the supposed rate of dip per mile; but it has been found that in nearly all cases these were underestimates of the actual thickness of the formations. Furthermore, these estimates seem to have been regarded by many geologists as the maximum estimate for the thickness of the rocks and for this reason they were inclined to regard them as an overestimate for the probable thickness of the formations.

In a communication recently presented by an able geologist to a geological society it was stated that the Utica shale at Syracuse, New York was one thousand feet below the surface.[2] When we remember that a well was drilled at Syracuse to the depth of 1969 feet, that it stopped in the gray Medina and that below this is the entire thickness of the Hudson group before reaching the Utica shale, then we have an idea of the difference between the popular notion of the thickness of these rocks and their actual thickness. On this account it seems desirable to compile general geological sections for New York state; giving, so far as possible, the thickness of the different formations as obtained from these well records. The section selected for this paper is one ranging geologically from the Barclay coal of Pennsylvania to the Archean of Ontario, Canada. Geographically the section extends northward from Barclay, Bradford county, Penn'a, passing near Elmira, Ithaca, Seneca Falls, Clyde and Wolcott, New York, and under lake Ontario to Canada. It is appoximately along a line somewhat east of the 77th meridian and may be called the section of western central New York.

RECORDS OF THE WELLS.

First, a condensed record of each well will be given and then a general geological section, compiled in the main from these records. The wells will be taken up in geographical order, commencing with the southern and proceeding northward.

The Bird Creek well is located near the center of the north-

[2]American Geologist, vol. v. (February, 1890), p.118.

ern boundary line of Wells township, Bradford county, Penn., not far from Wells station on the Tioga Division of the New York, Lake Erie and Western R. R. It is eighty rods south of the 77th mile stone of the state line between New York and Pennsylvania, and about eight miles southwest of Elmira, New York. Drilling was commenced November 15th, 1887 and finished April 17th, 1888. The well produced no oil; but a small amount of gas was obtained at a depth of 348 feet. At 371feet a little salt water was found and at about the same depth a vein of mineral water. The altitude of the mouth of the well is about 1600 feet A. T., according to Mr. Wm. Brown, to whom I am indebted for the samples of drillings. The well commenced in the upper part of the Chemung group and at a depth of about 930 feet there was a change from the greenish-gray, micaceous sandstone chips to those of greenish-blue or blue argillaceous shales, which are probably the upper part of the Portage group. The well was drilled to a depth of 2710 feet, without reaching the Genesee black shale, which indicates in this well a thickness of more than 1780 feet for the Portage. Or, since there is some doubt as to the line of separation between the Chemung and Portage, it shows that in southern New York, near the meridian of Elmira, the combined thickness of the Chemung and Portage groups is considerably more than 2700 feet.

Section of the Bird Creek Well.

	Depth	Thickness	
			Altitude, estimated, 1600′ A. T.
Chemung.	400′	....	First sample, greenish, non-calcerous sandstone.
	750′	....	Greenish-gray, micaceous sandstone, slightly calcareous.
		930′	
	880′	....	Chips partly from light gray sandstone; but mostly from a slightly purplish sandstone, which is somewhat calcareous.
	930′		Greenish-blue, non-calcarcous, argillaceous shale which is probably in the upper part of the Portage.
Portage.		1780′	The specimens from the remainder of the well are nearly all of greenish or bluish tint, are mostly from argillaceous or arenaceous shales which are usually non-calcareous. At 2700′ the chips are from a dark blue, finely arenaceous shale, which is slightly calcareous.
	2710′	....	The last sample from the bottom of the well, at 2701′ is a bluish to greenish-gray, fine grained, arenaceous rock, which is very slightly calcareous; also, there is blue argillaceous shale.

Section of well drilled at Ithaca, Tompkins county, New York. Location in the valley, one-fourth of a mile south of Ithaca.

Depth.	Thickness.		
		Altitude 396′ A. T.	
	340′	Portage shales and sandstones.	
340′	100′	Genesee black shale.	
440′	30′	Tully limestone.	
470′	1142′	Hamilton shales and sandstones.	
1612′	82′	Marcellus black shale.	
1694′	78′	Corniferous limestone.	
1772′	13′	Oriskany sandstone.	
1785′	115′	Lower Helderberg limestones.	
1900′		Approximate top of the Salina group.	Salina. Group. 1285′
	344′	Magnesian limestones, calcareous shales and some gypsum.	
2244′	24′	1st rock salt stratum.	
2268′	6′	Shale.	
2274′	54′	2d rock salt.	
2328′	12′	Shale.	
2340′	17′	3d rock salt.	
2357′	31′	Shale.	
2388′	21′	4th rock salt.	
2409′	67′	Shale.	
2476′	42′	5th rock salt.	
2518′	24′	Shale.	
2542′	48′	6th rock salt.	
2590′	60′	Shale.	
2650′	4′	7th rock salt 4′—6	
2654′	18′	Shale.	
2672′	42′	8th rock salt.	
2714′	6′	Shale.	
2720′	180′	Greenish shale.	
		Dark gray shale.	
2900′			

Salina	2906′	6′	9th rock salt, 6′-8′.
	2912′	....	Some salt crystals.
	2922′	....	Green shale.
	2944′	279′	Salt crystals, the last seen.
	3022′	....	Traces of mottled red and green shales.
			Green Shale.
	3046′	....	Mottled red and green shales. Most of the shale is green, but there is some red and green mottled.
	3130′	....	Last sample.
	3185′	——	Bottom of well according to the contractor, Mr. Rust.

The Ithaca well passed through from 1230′-1285′ of the Salina and only reached the first of the red and green mottled shales above the red shale.

For some additional information in reference to the Ithaca well see Trans. Am. Inst. Min. Eng., vol. XVI, pp. 941, 942. Also, N. Y. Ass. Doc. '89, No. 43, p. 22 and charts II, III and IV.

Section of well drilled at Seneca Falls, Seneca county, New York. Location in the Seneca River valley in the eastern part of the village.

			Altitude, approximately, 385′ A. T.
Salina group.		200′	Drab colored, impure limestones.
	200′	100′	Blue marls with an occasional red and green chip.
	300′	400′	Greenish-gray marls and drab colored limestones.
	700′	250′	Mostly bright red shale; but some mottled red and green shale.
	950′	400′	Dark blue limestone and shale in the upper part with greenish shales at the base.
			Niagara and Clinton groups.
	1350′	150′	Red shales and sandstones of the Medina group.
	1500′	——	Bottom of the well.

This well commenced in the upper part of the Salina group and was drilled to the depth of 1500′, the last 150′ being in the Medina group.

See Trans. Am. Inst. Min. Eng. vol. XVI, pp. 949, 950.

Section of well drilled at Clyde, Wayne county, New York. Location in Clyde village.

			Altitude, approximately, 389′ A. T.
Salina.	152′	152′	Gray, green and blue marls with gypsum.
		156′	Red marls.
	308′	32′	Blue and green marls, probably Salina.

Clinton & Niagara.	340′	110′	Dark blue limestone, upper division of Niagara.
	450′	225′	Shaly limestone of Niagara.
	675′		Approximate top of the Clinton group.
		83′	Sample from 675′-690′ has a reddish tint, some of the chips are greenish and two are oölitic iron ore.
Medina	758′	24′	Red shale of Medina.
	782′	3	Greenish, gray siliceous sandstone; the "Gray band."
	785′	915′	Red shales alternating with red sandstones and forming the Red Medina.
Hudson	1700	92′	Gray sandstone of Oswego (Vanuxem).
	1792		Bottom of well.

See Trans. Am. Inst. Min. Eng. vol. XVI, pp. 942,943.

Section of well drilled at Wolcott, Wayne county, New York. Location in the ravine at Wolcott village.

		Altitude, approximately, 317′ A. T.
	230′	Shaly layers of Niagara limestone above and Clinton below.
		220′ Oölitic iron ore of Clinton.
230′	690′	Red shale alternating with red, siliceous sandstone, forming the Red Medina.
920′	210′	Oswego sandstone of Vanuxem.
1130′	170′	Some blue shale alternating with gray, siliceous sandstone, similar to the Oswego sandstone.
1300′	650′	Undoubted Hudson blue shale.
		Utica shale.
1950′		Top of Trenton.
		Limestone alternating with shaly, calcareous layers.
2092′	50′	Gas.
2330′	7	Largest flow of gas.
2700′		Bottom of well, yet in the Trenton limestone.

See Trans. Am. Inst. Min. Eng. vol. XVI, pp. 943, 944.

From a partial record of a well drilled in Ontario, Wayne county, New York it seems probable that the bottom of the Wolcott well is within about 100′ of the base of the Trenton group, below which is perhaps 150′ of Calciferous limestone before the Archean would be reached.

From these well sections has been compiled the following general section giving the thickness of the different geological formations, together with the total thickness of the series from the lowest Coal Measures down to the Archean. The thickness of the formations from the Barclay coal to the top of the Portage is estimated, while for the remainder of the series it has been obtained from the wells drilled at Bird Creek, Ithaca, Seneca Falls, Clyde, Wolcott and Ontario.

A general geological section of Western Central New York.

Depth	Thickness	Formation	Remarks
	1000′	Barclay lower coal. Pottsville conglomerate. Mauch Chunk red shale. Pocono gray sandstone. Catskill.	Estimated.
1000′			
	1200′	Chemung.	Estimated.
2200′			
	1780′	Upper Portage. Ithaca group. Lower Portage.	Record from Bird Creek well which does not reach the bottom of the Portage.
3980′			
	100′	Genesee shales.	
4080′			
	30′	Tully limestone.	
4110′			
	1142′	Hamilton.	
5252′			
	82′	Marcellus shales.	
5334′			
	78′	Corniferous limestone.	
5412′			
	13′	Oriskany sandstone.	
5425′			
	115′	Lower Helderberg limestones.	
5540′			
	1418′	Salina.	
6958′			
	335′	Niagara limestone and shales.	
7293′	.....	?	
	83′	Clinton.	
7376′			
	942′	Red Medina; sandstones and shales.	
8318′			
	210′	Oswego sandstone.	Hudson Group
8528′			
	170′	Transition from Oswego sandstone to Hudson shales; gray sandstone and blue shales.	Hudson Group

8698′		
	650′	Hudson River group and Utica shale.
9348′		
	842′	Trenton limestone.
10190′		
	150′	? Calciferous limestone.
10340′		
		Archean.

In order to show the relation of the above section to our previous knowledge a general geological section, ranging through the same series of formations, has been compiled from the books. In the compilation of this section the maximum thickness of the formations, as near the line of section as possible, has been taken. The notes following the section give the authority and reference to the work in which may be found the statement of the thickness of the various formations.

A generalized geological section along the meridian of Cayuga lake, from the Barclay coal of Pennsylvania to the Archean of Ontario.

		Barclay coal.	
	(1) 1000′	From the Barclay lower coal to top of the Chemung.	Pottsville conglomerate. Mauch Chunk shale. Pocono sandstone. Catskill.
1000′			
	(2) 1200′	Chemung, both in Penn. and New York.	
2200′			
	(3) 1300′	Upper Portage of H. S. Williams Ithaca group of Vanuxem. Lower Portage of H. S. Williams.	Portage of H. S. Williams.
3500′			
	(4) 100′	Genesee shale.	
3600′			
	(5) 20′	Tully limestone.	
3620′			
	(6) 1000′	Hamilton.	
4620′			
	(7) 50′	Marcellus shale.	
4670′			
	(8) 100′	Corniferous and Onondaga limestones.	
4770′			
	(9) 5′	Oriskany sandstone.	
4775′			

	(10) 110′	Lower Helderberg limestones.
4885′		
	(11) 1000′	Salina.
5885′		
	(12) 140′	Niagara limestone and shales.
6025′		
	(13) 80′	Clinton.
6105′		
	(14) 600′	Medina.
6705′		
	(15) 1000′	Hudson.
7705′		
	(16) 300′	Utica shale.
8005′		
	(17) 750′	Trenton.
8755′		
	(18) 80′	?Calciferous.
8835′		
		Archean.

Authority and reference for the thickness of the formations, as given in the preceding section.

1. Dr. Henry S. Williams. On the Fossil Faunas of the Upper Devonian along the meridian of 76° 30′ from Tompkins county, N. Y., to Bradford county, Pa. Bull. U. S. Geol. Surv., No. 3, p. 28.
2. *Idem. Loc. cit.* pp. 25, 26 and 29.
   See Trans. Am. Inst. Min. Eng., vol. XVI. p. 945.
   The Chemung in New York was estimated by Prof. Hall to have a thickness of 1500′ (Geol. of N. Y., Pt. IV, p. 260); this did not include 300′ of the Upper Chemung in Pennsylvania, but did include the Upper Portage of H. S. Williams and the Ithaca group of Vanuxem both of which Dr. Williams has referred to the Portage. Dr. Williams' estimate for this series was 1950′ (Trans. Am. Inst. Min. Eng., vol. XVI, p. 945).
3. Dr. Williams estimates the Portage, which is subdivided into the Upper Portage, Ithaca group and Lower Portage, as 1300′ in thickness (Bull. U. S. Geol. Surv., No. 3. p. 21). Vanuxem estimated the Ithaca group as about 400′ (Geol. of N. Y., Pt. III, p. 174) which is regarded by Dr. Williams as 450′ in thickness (Trans. Am. Inst. Min. Eng., vol. XVI, p. 945). Vanuxem said that "the wall of rock at Ithaca can not be less than about 400′ thick"; but this probably included some of the Lower (?)

and Upper (?) Portage. Vanuxem called the Portage group, which corresponds to the Lower Portage of Williams, 150′ thick (Geol. N. Y., Pt. III, p. 170), this is estimated by Dr. Williams to be 250′ in thickness (Trans. Am. Inst. Min. Eng., vol. XVI, p. 945).

4. Vanuxem said that "in the ravines east of Ludlowville [near the eastern shore of Cayuga lake], the slate [Genesee] ....cannot be less than from eighty to one hundred feet in thickness" (Geol. N. Y., Pt. III, p. 169).

5. Prof. S. G. Williams says "On both sides of Cayuga lake the thickness of the undoubted Tully varies from twelve feet at King's Ferry to a maximum of eighteen and one-half feet.... ....In the Owasco lake valley, the general thickness is somewhat greater than on Cayuga lake." One section in this latter valley is twenty-three feet thick (6th Ann. Rep't of the State Geologist [N. Y.] for the year 1886, p. 19).

6. Hall wrote "the thickness of this group [Hamilton] on the eastern limit of the district [fourth geol. district,'Cayuga lake region] cannot be less than 1000 feet" (Geol. N. Y., Pt. IV, p. 194). Vanuxem gave the maximum thickness as 700′ (Geol. N. Y., Pt., III, p. 151). While Dana states that "the greatest thickness—about 1,200 feet—is found east of the centre of the state." (Man. of Geology, 3d Ed., p. 266).

7. Hall, Marcellus shale 50′ (Geol. N. Y., Pt. IV, p. 179).

8. Corniferous limestone 35′ Hall (*Ibid*, p. 168); Onondaga limestone 20′ at Williamsville, Erie county, N. Y., (*Ibid* p. 157), both 55′ in thickness. Prof. S. G. Williams calls it 100′ thick (Ithaca Daily Journal, April 19, 1887).

9. Vanuxem, Oriskany sandstone is nearly three feet in thickness near Springport, on Cayuga lake (Geol. N. Y., Pt. III, p. 127). Prof. S. G. Williams gives the thickness as three feet eight inches for the same exposure (Am. Jour. Sci., 3d ser., vol. XXX, p. 212).

10. Prof. S. G. Williams, Lower Helderberg limestones 110′ (*Ibid* pp. 212, 213); also, 120′ thick (Ithaca Daily Journal, April 19, 1887).

11. Dana says "they [Salina beds] are 700 to 1000 feet thick in Onondaga and Cayuga counties (Man. of Geol. 3d Ed.,p. 233); also, see *idem* p. 236. See Dr. F. E. Engelhardt's record of the Jamesville well, 8 miles south-east of Syracuse, which was commenced on top of the waterlime and at a depth of 1040′ had not reached the bottom of the red shales, which form the lower part of the group. (Ann. Rep't Sup't Onondaga Salt Springs, for 1881. N. Y. Assembly Doc. 1882, No. 16, p. 20.)
Ibid. for 1884. *Ibid.* 1885, No. 32, p. 18.
Ibid. for 1888. *Ibid.* 1889, No. 43, pp. 23, 24 and chart No. II., Sir William Logan stated that "it [Salina] attains its greatest

thickness, which is about 700′, in Wayne county" (Geol. Surv. of Canada. Rep't of Prog. from its Commencement to 1863, p. 346).

12. According to Hall the shale of Niagara group at Wolcott, Wayne county "is little less than 100 feet" and the limestone "is apparently not more than 30 or 40 feet thick in Wayne county" (Geol. N. Y., Pt. IV, p. 97).
13. The thickness of the Clinton group in Wayne county is somewhat less than 80′ (Hall: *Ibid.* p. 66).
14. Hall's report says "Its [the Medina] greatest width is on the Niagara river; but here a large portion of it is excavated on the north, leaving probably less than half its original extent within the state. From the width here exposed, the thickness actually measured, and the rate of dip to the southward, there is about three hundred and fifty feet of the rock between the mouth of Niagara river and the termination of the rock above Lewiston............This rock thins out entirely in an easterly direction in Oneida county." (*Ibid.* p. 43). At Rochester, N. Y., somewhat less than 600′ (Logan: Geol. Surv. of Canada. Rep't of Prog. from its Commencement to 1863, p. 310).
15. The Hudson group is from 800 to 1000 feet thick in central and northwestern New York (Hall: Geol. Surv. N. Y., Palæontology, vol. III, pt. I, text, p. 20, foot note). It is 770′ thick on the east side of the township of Collingwood, on Nottawasaga bay, at the head of Georgian bay, Ontario. (Logan: Geol. Surv. of Canada. Rep't of Prog. from its Commencement to 1863, p. 213).
16. The Utica shale is "250 feet in Montgomery county; 300 in Lewis county" (Dana: Man. of Geology, 3d Ed., p. 196). The Campbell well, three miles west of Utica, passed through 710′ of Utica shale and there are surface outcrops in the Mohawk Valley (?) of 600′ (Walcott: Proc. Am. Ass. Adv. Sci., vol. XXXVI, p. 212).
17. Vanuxem stated that "the greatest thickness of the Trenton limestone is in Lewis county............where it cannot be less than three hundred feet" (Geol. N. Y., Pt. III, p. 49). Emmons called it 400′; (Geol. N. Y., Pt. II, p. 116). In Ontario, Canada, north of Ontario, Wayne county, N. Y. it is 679′ (Logan: Geol. Surv. of Canada Rep't of Prog. from its Commencement to 1863, p. 186); and along the Trent river about 750′ (*Ibid.* p. 188).
    In the Campbell well, near Utica, about 430′; surface outcrops 290′ (Walcott: Proc. Am. Ass. Adv. Sci., vol. XXXVI, p. 212).
18. Logan wrote under the heading of the "Calciferous formation" that "On the west side of the ridge [Laurentian], follow-

ing the Potsdam where this is present and resting on the Laurentian series where it is wanting, there are generally met with thirty or forty feet of strata almost destitute of organic remains and about the same amount with a few fossils insufficient to determine the age of the strata with certainty." (Geol. Surv. of Canada. Rep't of Prog. from its Commencement to 1863, pp. 118, 119). Also, "to the westward of the Laurentian ridge of the Thousand Islands, there are about eighty feet of strata, the age of which is not very clear" (*Ibid.* p. 177 and see p. 182).
Calciferous and arenaceous strata in the Campbell well, near Utica, about 360'; surface outcrops 350' (Walcott: Proc. Am. Ass. Adv. Sci. vol. xxxvi, p. 212).

Taking the sum of these maximum estimates and we have a series of rocks 8835' in thickness between the lowest or Barclay coal and the Archean.

But in the State well at Syracuse, as reported by Dr. F. E. Engelhardt, it is 1237' from the top of the Niagara to the bottom of the red and brown Medina. (See Ann. Rep't Sup't Onondaga Salt springs, for 1884. N. Y. Assembly Doc., 1885, No. 32, pp. 15-17; and, Trans. Am. Inst. Min. Eng., vol. xvi, p. 944). The thickness of the same series, and including the Oswego sandstone, is given in the books as 820', or 417' less than the actual thickness at Syracuse. Adding this correction to the 8835' and we have for the general section a total thickness of 9250'.

Geologists did not generally use these maximum estimates of thickness, as has been shown by their estimates of the depth at which certain formations might be reached. The Ithaca test well affords a good illustration of the above statement and others might be given. The mouth of the well is geologically at about the top of the Lower Portage of Dr. H. S. Williams and the objective point was the Trenton limestone. Estimates of the depth to which it would be necessary to drill, in order to reach the Trenton, were furnished the company by several geologists. One estimated the thickness of the formations to be penetrated in drilling the well as follows:

Portage and Hamilton	1030'
Corniferous limestone	100'
Lower Helderberg -	120'
Salina. - -	700'
Niagara, including Clinton and Medina -	150'
Hudson group and Utica shale - -	200'
Total - -	2300

This estimate located the top of the Trenton limestone at a depth of 2300′ and the bottom of the formation at a depth not exceeding 2800′. (See article on "Oil and Gas. Do they exist in this region?" Ithaca Daily Journal, April 19, 1887).

Taking the thickness of this series of rocks from the generalized section of maximum thickness and we have 4755′ as the depth of the top of the Trenton limestone at Ithaca, N. Y. The thickness of this series, as shown by continuous well sections in the preceding general section, is 5708′ or 953′ more than the supposed maximum thickness of this series. If the record of the state well at Syracuse be considered then the maximum estimate to the top of the Trenton limestone would be 5172′, or 536′ less than the probable thickness of these formations.

U. S. Geological Survey, June, 1890.

ARTESIAN WELLS IN NORTH AND SOUTH DAKOTA.

By WARREN UPHAM, Somerville, Mass.

[Read before the Minnesota Academy of Natural Sciences, June 10, 1890.]

On the broad fertile plain called the Red river valley, which was the bed of the glacial Lake Agassiz, many artesian wells have been obtained within the thick drift sheet, deriving their supply of water from porous beds or veins of sand and gravel beneath, and frequently between, deposits of boulder-clay or till. The depths of these wells vary from 40 to about 250 feet, and the hight to which the water is capable of rising is often only a few feet and seldom more than 25 to 50 feet. Hundreds of these flowing wells, commonly one to two inches in diameter of pipe, are in use on farms, at grain elevators, and for the supply of towns, on both the Minnesota and North Dakota sides of the Red river. Some tracts of considerable area, however, fail to find artesian water, but even these generally encounter water-bearing layers at depths corresponding with those of the artesian wells, from which water rises nearly to the surface.

The narrow areas that may be sometimes occupied by the sand and gravel layers yielding artesian water, or the thin and in some places entirely deficient condition of these layers, is illustrated by the different depths at which a flow of water was first encountered by four wells in the village of Grandin, North Dakota. These

wells are on an area only about fifty rods in extent, and their several depths are 105 feet, 158 feet, 187 feet, and 248 feet. Either the upper water-bearing beds here are narrow, like a stream course, so that they were not found by the deeper wells, or, if they exist as sheets of great width as well as length, they are in some parts thinned out, allowing the impervious till above to rest on that below. But in the direction from which the water supply is received, these gravel and sand veins or beds must have a great extent and descend from levels higher than the central part of the Red river valley, where the artesian wells are situated. At least this must be the case where the water is fresh or only very slightly saline, as at Grandin and in all the southern part of the valley as far northward as the vicinity of Crookston in Minnesota and Blanchard in North Dakota, and in a large district of Manitoba including Winnipeg and the Mennonite reserve east of the Red river.

North of Crookston and Blanchard to the international boundary and in the south edge of Manitoba, the water of these wells, almost without exception, is distinctly saline and alkaline. It seems very probable that the water-bearing beds of that large portion of the Red river valley differ widely in the origin of their water supply from the foregoing. Instead of deriving their water, like the fresh artesian wells, from rainfall upon higher parts of the drift surface contiguous to the Red river valley, there seem to be good reasons for believing that the brackish water is mainly from the basal sandstone of the Cretaceous series, coming through that sandstone from its outcrops on the flanks of the Rocky Mountains and Black Hills, and permeating upward into the drift of the Red river valley from areas where this sandstone is the underlying bed-rock.

Deep artesian wells of somewhat saline and alkaline water, like that of the part of the Red river valley just described, are obtained on a belt that extends across North and South Dakota from Devil's Lake to Yankton and Vermillion, including the greater part of the James river basin. Wherever borings along this belt have penetrated to the Dakota sandstone, the lowest formation of the Cretaceous series in the Upper Missouri region, artesian water has been found. Probably as many as a hundred wells have been bored, their depths ranging from 900 to 1,550 feet, except in the southern part of the James and Vermillion valleys, where many

wells are only 600 to 750 feet deep, and a few, the farthest southeast, are between 300 and 400 feet in depth. These wells are mostly five or six inches in diameter, and their strong pressure, commonly from 50 to 175 pounds per square inch at the surface, makes them valuable not only for fire-hydrants, but also to furnish power for manufacturing purposes. Several wells have been bored at Aberdeen, and three years ago fifteen wells were in use in Yankton. The pressure of the wells in Yankton is sufficient to raise the water 129 feet, and in numerous places along the middle portion of the James river valley, as Huron, Redfield, and Aberdeen, the pressure corresponds to a rise of more than 400 feet above the surface.

The sections of these deep wells in North Dakota and on the high land between the James and Missouri rivers in South Dakota include, beneath the drift, the Fort Pierre, Niobrara, and Fort Benton divisions of the Cretaceous series ; but along the lower part of the James river and on the Vermillion, erosion during the Tertiary era removed the upper portion of these beds, leaving only the Fort Benton shales or a part of that formation over the Dakota sandstone.

At Devil's Lake, where an artesian well was bored last year, about six feet above the depot, or 1,470 feet above the sea, the section was as follows :—

Section of Well at Devil's Lake.

Glacial drift, till as on the surface	25 feet
Dark shale, nearly alike through its whole thickness, including the Fort Pierre and Fort Benton formations, with no noticeable calcareous beds at the intermediate Niobrara horizon	1,403 feet
Gravel, of granitic pebbles up to a half inch in diameter, firmly cemented with nodular pyrite	3 feet
Dakota sandstone, or rather a bed of loose sand, very fine, white or light gray, the base of which was not reached	80 feet
Total	1,511 feet

From the sandstone, at the depth of 1,470 feet, artesian water came up with a rush, but sand soon filled the pipe so that the supply became small. It is from this level that the present flow comes, through narrow slits cut in the pipe. The boring was continued 40 feet deeper, but no such strong flow was obtained

below. In July, 1889, when the well was completed, it supplied 1,800 barrels of water in 24 hours, or about 40 gallons per minute, the diameter of the pipe being 8 inches, reduced to 3½ inches in the lower portion. The stream flowing away was then turbid with the exceedingly fine particles of sand brought up from the bottom.

The Jamestown well, bored in the winter of 1886-87, about eight feet below the depot or 1,400 feet above the sea, went through a similar section of about 1,400 feet of shales, with no distinctly different portion to indicate the place of the Niobrara formation. The same nearly uniform section has also been found to a depth of 1,350 feet at Deloraine, in Manitoba, close northwest of the Turtle Mountain, as I am informed by Mr. J. B. Tyrrell of the Geological Survey of Canada. At that depth, which was bored last year, there still lacked about 300 feet of reaching the sea level, from which the Devil's Lake artesian water rises.

For the greater part of my notes of the artesian wells of South Dakota, also of Ellendale and Oakes in North Dakota, I am indebted to *Resources of Dakota*, published by the territorial Commissioner of Immigration in 1887, and to recent correspondence with Prof. G. E. Culver, of the University of South Dakota, and with Prof. C. W. Hall, of the University of Minnesota. These data, with those obtained by me at Devil's Lake and Jamestown, I have placed in tabular form for convenient comparison, showing (1 and 2) the distances of the localities north and west from the mouth of the Big Sioux river at the southeast corner of South Dakota; (3) depths of the wells; (4) their pressure at the surface, wherever it has been obtainable, in pounds per square inch; (5) the corresponding hight or head to which the water would rise above the surface; (6) the altitude, with reference to the sea level, of the source of the artesian water in the Dakota sandstone; (7) the altitude of the surface; and (8) the hight of the computed head of water above the sea.

The flow of water from the Dakota sandstone at Devil's Lake is found exactly at the sea level, but the top of the sandstone formation is 39 feet higher. At Jamestown the flow rises from a depth of 76 feet below the sea level, indicating that the top of the Dakota sandstone there sinks slightly lower than at Devil's Lake. Along the distance of eighty-five miles from north to south be-

tween these points, its level is probably nearly constant; and borings at intervening towns, as New Rockford and Carrington, will doubtless find artesian water at or slightly below the sea level. Farther south, the top of the sandstone and its water supply are found throughout a large district of South Dakota and the south edge of North Dakota at a plane 250 to 450 feet above the sea.

Artesian Wells deriving water from the Dakota sandstone in North and South Dakota.

LOCALITY.	Dist. in miles on lat. & lon. from the S. E. corner of So. Dakota.		Depth in feet.	Pressure at surface in pounds per sq. inch....	Head above surface, in ft., computed from pres.	Altitudes in feet above the sea.		
	NORTH.	WEST.				Source of water in upper part of Dakota sandstone.	Surface, railroad at station	Head computed from pressure........
Devil's Lake...	390	119	1511			0	1464	
Jamestown....	305	110	1476	95	219	-76	1408	1619
Oakes..........	252	80	944			378	1322	
Ellendale......	243	101	1087	125	288	362	1449	1737
Britton........	228	72	1004			350	1354	
Columbia......	216	92	965	175	404	339	1304	1708
Andover.......	202	72	1070	90	208	406	1476	1684
Groton	204	82	960	187*	432	344	1304	1736
Aberdeen......	206	101	908	175	404	392	1300	1704
Ipswich........	204	127	1270	70	162	260	1530	1692
Mellette.......	186	101	900			400	1300	
Ashton.........	174	101	915	50*	115	381	1296	1411
Doland........	167	81	950			405	1355	
Redfield.......	166	103	900	175	404	395	1295	1699
Faulkton......	176	132	1210			363	1573	
Hitchcock.....	148	97	950	175	404	389	1339	1743
Huron.........	130	88	863	175	404	424	1287	1691
Miller.........	140	126	1148	125	288	439	1587	1875
Highmore.....	141	148	1552	25	58	338	1890	1948
Harold........	141	163	1453			348	1801	
Woonsocket...	108	91	750	153	353	558	1308	1661
Letcher.......	97	85	600			700	1300	
Mitchell.......	84	79	600			701	1301	
Plankinton....	85	102	750			778	1528	
Kimball.......	87	126	1068			720	1788	
Vermillion.....	20	24	365	15	35	785	1150	1185
Meckling......	23	31	338			818	1156	
Yankton.......	27	46	610	56	129	586	1196	1325
Tyndall........	34	71	730			688	1418	
Ft. Randall....	38	106	600	45	104	660	1260†	1364

*The pressure reported at Ashton is 100 or 125 pounds less than would be expected in proportion with other localities; and at Groton it is somewhat more. The discrepancy of the latter, however, is no greater than may be due to superior permeability of the water-bearing stratum.

†Approximate altitude of high water of the Missouri river at Fort Randall.

Continuing still southward, from Woonsocket to the Missouri river, the water-bearing stratum rises to altitudes from 558 feet to 818 feet above the sea, the highest levels being at Meckling and Vermillion, the most southeastern localities of this list.

The same southeastward ascent of the Dakota sandstone reaches to its outcrops on the southwest side of the Missouri in Dakota county, Nebraska, whence its name is derived, opposite to the southeast corner of South Dakota. There and at other extensive outcrops in Western Iowa and Eastern Nebraska, having approximately the same elevations as the surface at Vermillion and Yankton, the water coursing through this sandstone finds outlet in springs; and these avenues of discharge explain the gradual reduction in the altitude of the head of water above the sea level, as the series of wells is followed from north to south and from west to east. Somewhat uniform altitudes of 1,619 to 1,743 feet are recorded as the hights to which water would rise in pipes for all the wells, where pressure is reported, from Jamestown to Huron and Woonsocket, excepting those west of Huron, which will be considered later, and the well at Ashton, where the reported pressure is probably erroneous, lacking 100 pounds or more of its true amount. At Hitchcock the head of water has a computed altitude of 1,743 feet above the sea; eighteen miles to the south, at Huron, it is 1,691 feet; twenty-two miles farther south, at Woonsocket, it is 1,661 feet; and eighty-one miles still farther south, at Yankton, it is only 1,325 feet.

Equally distinct gradients of the plane of water head are found descending from west to east on and near the latitudes of Huron and Yankton. Thus at Highmore, sixty miles west of Huron, the head is 1,948 feet above the sea; at Miller it has declined 73 feet in a distance of twenty-two miles to the east; and in the thirty-eight miles thence to Huron it falls 184 feet more. Between Fort Randall and Yankton, in a distance of sixty miles from west to east, this plane descends at least 40 feet, but the descent is more if the well at Fort Randall is at a considerable hight above the Missouri river. In the next twenty-two miles eastward to Vermillion the descent is 140 feet. This feature of the artesian water supply is caused, as before stated, by its outlets through springs in outcrops of the Dakota sandstone, which begin thirty to forty miles southeast of Vermillion and extend thence southeast and south.

All the eastern outcrops of the Dakota sandstone are lower than the upper portions of the James river basin and the wells farther west at Highmore and Harold. These outcrops therefore cannot be the sources from which the sandstone receives its artesian water, but, as we have seen, they are the avenues of its natural outflow. We must look instead to the western outcrops of this formation, where it skirts the Black Hills and exposes its upturned edges along the base of the Rocky Mountain ranges, for the areas upon which water is carried downward into the sandstone. Thence we know this stratum to be continuous beneath the plains to the James river valley, for there are no nearer nor other inlets from which the copious supply of the artesian wells can come. At a plane of similar or greater depth an artesian reservoir exists beneath much, if not all, of the country westward to the mountains. The gradients of the altitudes to which the water of wells is capable of rising along east to west lines in South Dakota, as at Huron, Miller, and Highmore, are approximately the same as the average westward ascent of the country, demonstrating this western origin of the water supply, and indicating that such wells may be obtained upon an extensive region of the arid plains.

How far then can this artesian water be utilized for irrigation? Will it be practicable to store the water in reservoirs for use in the season of growing crops, and especially during severe droughts like that which so reduced, or in some portions entirely cut off, the crops in North and South Dakota last year? To this inquiry we may reply by computing the amount of water needed for irrigating a given space, as a quarter-section of 160 acres, the usual area of a homestead. Allowing a depth of twelve inches of water for this use during the growing season, the year's supply of water from a well flowing 100 gallons per minute is required, without allowance being made for leakage or evaporation from the reservoir. The Devil's Lake well would, therefore, irrigate only 64 acres, and the Jamestown well, flowing 375 gallons per minute will water less than a section one mile square. But each of these wells cost about $7,000, to which must be added the cost of the construction of reservoirs and irrigating ditches, placing the expense of such water supply far beyond its prospective value for ordinary agriculture.

An important objection, however, against the use of this water for irrigation seems to lie in its dissolved alkaline and saline matter, which must be left in the soil. After continued use in irrigation during many years, the residuum from this water would quite certainly prove injurious to crops, so that the land would become worthless. Such results have attended irrigation with only very slightly alkaline water on the alluvial plains of the arid northwestern provinces of India. The proportion of sulphate of soda in streams flowing down from the Himalayan range and in canals taking water from them varies from 9 to 43 parts in a million, and the proportion of common salt is from 0.23 to 15 parts; yet under the dry climate of northwestern India the natural evaporation of so nearly pure water, and its use in irrigation, have caused extensive tracts of land formerly productive to become barren.*

The analysis of the water of the Jamestown well, which doubtless closely resembles that of all the wells obtaining their supply from the Dakota sandstone, is given by Prof. James A. Dodge, University of Minnesota, as follows :—

Analysis of the mineral matter in the water of the artesian well at Jamestown, North Dakota.

	Parts per million.	Grains per gallon.
Silica	35.7	2.0823
Alumina	3.5	.2041
Carbonate of iron	2.2	.1283
Carbonate of lime	188.0	10.6743
Sulphate of lime	249.0	14.5241
Sulphate of magnesia	154.2	8.9944
Sulphate of soda	1139.4	66.3602
Sulphate of potash	81.5	4.7523
Chloride of sodium	369.1	21.5296
Phosphates	Traces	
Totals	2222.6	129.2496

The quantities of alkaline matter and salt are sufficient to give the water a brackish taste, rendering it unpalatable for drinking and unfit for ordinary domestic uses; but it is drunk freely by cattle and horses, with no unfavorable effects. These dissolved mineral ingredients seem to have been derived from the Cretaceous shales, and probably in part from beds in the Dakota formation, with which the water has been in contact during its slow percola-

*Medlicott and Blanford, Manual of the Geology of India, pp. 413-415.

tion hundreds of miles through the sandstone. They are the same in kind and similar in amount with the mineral matter of Devil's lake, concentrated by evaporation without outlet from the water of inflowing streams and springs, which bring very small amounts of these salts dissolved from the drift and Cretaceous shale of the adjoining country.

Much shale, gravel and detritus, rich in sulphates, are present in the glacial drift over nearly the entire Red river basin, and the percolating rain-water, found by the fresh artesian wells in the drift of the southern and northern ends of the Red river valley, has acquired minute quantities of alkaline and saline matter. But where its proportion is large, as in the brackish water of the wells from Crookston and Blanchard northward to the edge of Manitoba, it seems impossible that so remarkable difference can be due to diversity in the material of the drift, or to longer time and better opportunity afforded to the water for such impregnation while percolating through porous beds or veins in the drift. The saline and alkaline artesian waters of the drift gravel and sand along this central portion of the Red river valley therefore appear to be received mainly from the same Dakota sandstone which supplies the deep wells of the James river valley.

Several wells in the vicinity of Blanchard and Mayville, 375 to 404 feet in depth, pass through the drift and enter a very fine white sandstone, probably the Dakota formation, from which they obtain flows of brackish water. About a dozen miles east of Blanchard the drift was found to have a total thickness of 310 feet, below which a boring went 107 feet into exceedingly fine white sandstone, finding, however, no artesian water, apparently because of the very close texture of the rock. The top of the sandstone in these wells is 650 to 575 feet above the sea. If it is the Dakota sandstone, as seems probable, it has an ascent of about 600 feet in 75 miles east from the meridian of Devil's Lake and Jamestown, rising in its approach toward the Silurian, Cambrian, and Archæan areas of Minnesota and Manitoba. It may be thus the bed-rock, on which the drift is deposited, beneath extensive tracts in the middle part and on the western border of the Red river valley, discharging there its alkaline and saline artesian water into the permeable beds of gravel and sand in the drift sheet, whence it rises in the brackish wells of that district.

Besides the classes or groups of artesian wells thus far considered, there remain to be mentioned numerous shallow flowing wells, from 20 to 168 feet deep, in the drift of the Vermillion river basin in South Dakota, reported by Prof. G. E. Culver, and two deep artesian wells in North Dakota at Tower City and Grafton. The wells in the vicinity of the Vermillion river are on an area unmarked by grand contrasts of elevation, though toward the north and northeast the surface gradually rises in the Coteau des Prairies. They seem to be comparable with the plentiful flowing wells or fountains along the Maple river in Blue Earth and Faribault counties, Minnesota.

The Tower City well, fifty miles east of Jamestown, is four feet lower than the depot, being 1,168 feet above the sea. Its depth is 670 feet, through drift, 163 feet; Cretaceous shales, with occasional beds of sandstone, 502 feet; and quicksand, into which the boring advanced only 5 feet. Salty and alkaline water outflows 94 gallons per minute, and is capable of rising 33 feet above the surface. The scanty flow and low head of this well suggest that the water bearing stratum may be enclosed within the Fort Benton shales; but its altitude, 500 feet above the sea level, accords with that of the sandstone reached by wells at Blanchard and Mayville, so that more probably it is the top of the Dakota formation. The plane of the head of water supplied from this formation would show a marked descent northeastward, as is thus indicated at Tower City, and in less degree at Devil's Lake, in comparison with Jamestown and Ellendale, if there are abundant natural outlets of this artesian water along the Red river valley, as appears to be true, by springs rising through the drift. These brackish springs occur on many of the streams tributary to the Red river both in North Dakota and Minnesota, the most remarkable being on Forest and Park rivers, which therefore were formerly called the Big and Little Salt rivers.

At Grafton, in the Red river valley on the Park river, the artesian well, 825 feet above the sea, is 915 feet deep, going through (1) drift, 298 feet; (2) limestone, apparently the Lower Magnesian formation of the Cambrian series in southern Minnesota, [illegible] feet; (3) white sandstone, referred to the Jordan formation of the same series, 65 feet, yielding a copious flow of brackish water; (4) reddish, blue, and gray shales, with some arenaceous or cherty and dolomitic beds, representing the Saint Lawrence

tion hundreds of miles through the sandstone. They are the same in kind and similar in amount with the mineral matter of Devil's lake, concentrated by evaporation without outlet from the water of inflowing streams and springs, which bring very small amounts of these salts dissolved from the drift and Cretaceous shale of the adjoining country.

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ally. We do not know of it so far, in Esthonia, nor in Scandinavia. It may however be found there and in the British Isles, in Bohemia and the southern part of Europe.

II. The next formation or *Schmidtia* zone is in Russia, Scandinavia, the British Isles, and Bohemia. But outside of Esthonia it is only on stratigraphical principles; round Revel only a fauna has been discovered below the *Holmia* zone. So far we have nine species; one trilobite—*Schmidtia mickwitzi*, the oldest in the world, five forms of very low and imperfect brachiopoda, a problematic form called *Volborthella*, one Cystidæ and one *Medusites*. Certainly a very meagre representative fauna of all the forms of marine animals which developed rapidly during the Middle Taconic period.

The only formation, in the Nevado-Canadian sea, which may belong to the Esthonian or *Schmidtia* zone, is the Chuar formation of the grand Cañon of Colorado, where three doubtful forms of marine animals have been signalized. It may be that those few and badly preserved forms belong to a higher horizon, and that they may be classified finally in the Middle Taconic. But it is more prudent to let the Chuar formation into the Lower Taconic, for the present, and to regard it as representing in part, if not wholly, the infra-Primordial fauna strata.

III. The true Primordial fauna or Middle Taconic system begins with the *Holmia* zone or *Scandinavian* formation. At first that formation was considered in Scandinavia and in Newfoundland, as the lower part of the Paradoxides zone, to which it is closely allied by most intimate relations, stratigraphic as well as paleontologic. Although not so important in thickness, as the succeeding formation of the great *Paradoxides* zone, and not so rich in regard to the number of fossils and paleontologic sub-horizons, it posseses a well defined fauna of the greatest importance, on account of its forms, which fore-run and shadow forth the development of the whole primordial fauna discovered and created by the researches of Dr. Emmons and Joachim Barrande in 1844 and 1846.[1]

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(1) The discovery of the Taconic system with its special primordial fauna antedates the Cambrian system, as it is now put forward by English geologists, by eighteen years—1862 being the year of Salter's discovery of the primordial fauna *in situ* at St. David. Sedgwick did not find any fossils in the strata of the lower part of his primitive Cambrian, which remained in a state of complete confusion until Salter's re-

Its separation from the *Paradoxides* zone, made by the Scandinavian geologists, is well justified and is a good move in the classification. The names proposed are in harmony with the whole scheme of nomenclature used in geology, and recall the country where it was first discovered and the most characteristic form of fossil contained in it: Scandinavian formation, or *Holmia* zone.

Lately an unfortunate confusion has arisen from a too hasty identification of generic forms, which are widely separated; and the consequent parallelism and equivalency of the great Georgian formation or *Elliptocephalus* (*Olenellus*) zone with the Scandinavian formation, or *Holmia* (*Paradoxides-Olenellus*) zone is an error to be regretted, on account of the great publicity it has received, too hastily, at the International Congress of Geologists, London, in 1888.

Until now the Scandinavian formation has been found only at four localities in Scandinavia, two being near one another north of Christiania; and another one found in Lapland has not yet been described. In England, its existence has been signalized by professor Lapworth at one single locality, and in Newfoundland, since 1868, it is known in Conception bay. In all six outcrops of the Scandinavian formation fauna are actually known.

The number of fossils found, described or simply signalized is about forty species with a certain number of varieties. Thirteen species are actually known in Scandinavia; very likely three or four more species will soon be added by Dr. Holm when he has

searches, and he had no idea that there were two distinct systems inclosed in it. The confusion he made was cleared out first by Dr. Emmons in America, and afterward by Barrande in Europe; both of whom showed that below the fossiliferous strata found and described by Sedgwick, there was a great system of strata containing an older and special fauna, entirely unknown to Sedgwick and Murchison.

The Cambrian of Sedgwick, by all rules of priority and classification according to great faunæ, is confined to the second fauna, which, *mirabile dictu*, is called, by the actual geologists of the British empire, *Ordovician* by the Cambridge school, and *Lower Silurian* by the school of the Geological survey of England. The name *Champlain* given by Dr. Emmons, as far back as 1842 to the second fauna system, antedates Ordovician by thirty-seven years; and so long as the English geologists maintain their present classification against all right of priority, it is important for American geologists to use their national classification of Taconic system and Champlain system, for the strata containing the primordial and the second faunas, instead of Cambrian system for the primordial fauna and of Ordovician system for the second fauna, two names entirely unadapted to fulfill the rules used in geology for classification and nomenclature. (See for all the exact dates, my paper: "On the use of the name Taconic" in *Proceed. Boston Soc. Nat. Hist.*, vol. XXIII, p. 343, March, 1887).

published his materials collected in southern Lapland. We have only four species in England, thus making about twenty species for the Scandinavian formation of Europe. In Newfoundland we have also about twenty species. Total 40 species.

The trilobites are the most conspicuous forms in that fauna, some of them, like the genus *Holmia* attaining the dimensions of a moderate sized *Paradoxides*. The relations of the genus *Holmia* to *Paradoxides* and *Elliptocephalus* (*Olenellus*) has been very well pointed out and characterized by Dr. Holm. Brachiopods of very low forms and organization are found with a certain number of pteropods.

On the whole, the fauna of the Scandinavian formation does not yield much evidence in favor of the theorists on the origin and descent of species. So far the results are negative, as has been maintained with great force by the greatest of all the paleozoic paleontologists, M. Joachim Barrande.

IV. The great *Paradoxides* zone or *Bohemian* formation appears in more numerous patches and more widely scattered than the three preceding formations. As a consequence its fauna is much more developed than any of the previous ones, for all three of those number only about fifty species, while the *Paradoxides* zone fauna reaches about 270 species for the deposits of the Acadio-Russian sea, and of that number thirty belong to the great genus of *Paradoxides*.

In the Nevado-Canadian sea, the homotaxical fauna of the Bohemian formation, numbers already more than one hundred species, five or six of which represent the *Paradoxides*, under the form of a very closely allied genus, the *Elliptocephalus* (*Olenellus*).

On the whole, the faunas of the *Paradoxides* and *Elliptocephalus* (*Olenellus*) zones, which are in the main contemporaries and homotaxical, are composed of almost 400 species of marine fossils ; a considerable increase on the preceding faunas of the Scandinavian, Esthonian and Newfoundlandian formations.

As Barrande foreshadowed and announced forty years ago, the trilobite is the dominant family, and the most common forms of them revolve round the Paradoxidean type, as well in the Lower Taconic as in the Middle Taconic.

The following tables give a resumé of the parallelism of the four formations under consideration, and their equivalents in Europe and in North America.

Table I.—Europe (Eastern Part of the Acadio-Russian Sea.)

		Scandinavia and Esthonia.	British Islands.	Bohemia.	France.	Sardinia.	Spain.
Middle Taconic.	IV. Bohemian formation or Paradoxides zone.	Paradoxides slates. { 6. Agn. lævigatus. 5. Parad. forchhameri 4. Par. oelandicus. 3. Par. davidis. 2. Par. tessini.	Paradoxides zones of the Menevian and Harlech groups.	Paradoxides zone or primordial fauna of Ginetz and Skrey.	Paradoxides of Ferrals-les-Montagnes (Hérault.)	Paradoxides of the vicinity of Iglesias.	Paradoxides of Leon, Asturias and Saragozza.
	III. Scandinavian formation or Holmia zone.	Holmia slates—1 Parad? or Olenellus? or Holmia kjerulfi.	Beds of Caer-Caradoc—Olenellus? or Holmia callawei.	Unknown.	Unknown.	Unknown.	Unknown.
Lower Taconic.	II. Esthonian formation or Schmidtia zone.	Fucoid sandstone. Blue marl with Olen? or Schmidtia mickwitzi. Sandstone.	Longmynd group in part; but fuana unknown.	Division A. and B., or Azoic stage, representing stratigraphically the Lower Taconic.	Unknown.	Unknown.	Unknown.
	I. Newfoundlandian formation.	Unknown.	Unknown.				

Table II. America (Western part of the Acadio-Russian Sea.)

		Newfoundland.	New Brunswick.	Massachusetts.
MIDDLE TACONIC.	IV. Bohemian, or Paradoxides zone.	Paradoxides slates. Divisions E., D., C., B., of Mr. Matthew.	Paradoxides zone or Division 1, of Mr. Matthew.	The lower part only of the Paradoxides zone at Braintree, Boston.
	III. Scandinavian, or Holmia zone.	Holmia slates of Topsail and Manuel; Paradoxides? or Olenellus?	The Division O. of Matthew, is stratigraphically the Holmia zone.	Unknown.
LOWER TACONIC.	II. Esthonian, or Schmidtia zone.	Strata with fucoids and Archæocyathus below the Holmia zone.	Unknown.	Unknown.
	I. New Foundlandian, or the nontrilobitic zone.	Signal Hill sandstone and Aspidella slates near St. John's.		

Table III.—America (Nevado-Canadian Sea.)

		Vermont, New York, Canada, and Strait of Belle Isle.	Grand Canon of the Colorado.	Nevada and Utah.	British Columbia.
Middle Taconic.	IV. Georgia formation or Elliptocephalus (Olenellus) zone.	Elliptocephalus (Olen.) zone of Bald mountain, Georgia, Bic harbor and Belle Isle. Divisions *c.* and *a.* of Emmons.	Unknown.	Elliptocephalus (Olen.) zone at Eureka, Highland, Pioche, Wasatch, Ophir.	Elliptocephalus (Olen.) zone at Mount Stephens, near the Canadian Pacific railway.
	III. St. Albans formation.	Want a careful study. Division e. granular quartz of Emmons with Holmia?		Prospect Mountain quartzite.	
Lower Taconic.	II. and I. Chuar formation of the Grand Canon of Colorado.	Conglomerate and Talcose slates of Vermont?	At one third of the thickness of the formation in descending order, there is a discinoid shell, an obscure Hyolites and a fragment which may belong to a trilobite?	10,000 feet of strata exist below the Elliptocephalus zone in the Wasatch mountains, and belong mainly to the Lower Taconic.	10,000 feet of strata exist below the Elliptocephalus zone of Castle mountain which belong mainly to the Lower Taconic.

Table IV.—Synchronism of the formations in the Acadio-Russian and Nevado-Canadian Seas.

<table>
<tr><th></th><th>Acadio-Russian Areas.</th><th>Canadian Area.</th><th>Nevadian Area.</th></tr>
<tr><td rowspan="2">Middle Taconic.</td><td>IV. Bohemian formation or Paradoxides zone.</td><td>IV. Georgia formation. The lower part wants more study before we can know if it is the exact homotarical fauna of the whole Paradoxides zone.</td><td>IV. Georgia formation. In British Columbia it seems more developed and represents there the whole Paradoxides zone.</td></tr>
<tr><td>III. Scandinavian formation or Holmia zone.</td><td rowspan="2">III. and II. The St. Albans and Granular Quartz formations want to be explored and studied carefully before any correlation and synchronism is attempted with the Holmia and Schmidtia zones.</td><td>III. Unknown paleontologically.</td></tr>
<tr><td rowspan="2">Lower Taconic.</td><td>II. Esthonian formation or Schmidtia zone.</td><td>II. Grand Canon of the Colorado; small fauna referred with doubt to the Esthonian formation.</td></tr>
<tr><td>I. Newfoundlandian or Terreneuvien formation.</td><td>I. Unknown.</td><td>I. Unknown paleontologically, but represented stratigraphically in the Grand Canon, the Wasatch and Castle mountain.</td></tr>
</table>

The Physical Sketch map of the Lower and Middle Taconic period, accompanying this paper,* shows at a glance the supposed and conjectured *terra firma* and the seas, for the north temperate or neutral zone of about one-half of the northern hemisphere. Many years ago, in 1860, I tried to give a reconstruction of the lands and seas, as they existed during the Jurassic period, in my "Lettres sur les roches du Jura et leur distribution géographique dans les deux hemisphères", addressed to my much regretted friend, the late Albert Oppel. It was a bold attempt with very scanty material at my disposal.

However, as imperfect and conjectural as it was, it contained the first germ of geographical distribution by Homozoic bands and provinces in geological times, and opened a path which has been followed since, with more success, by several of my young contemporaries, notably by Messrs. Neumayr, Mojsisovics and Niti-

*See the June number, 1890.

kin for the Jura and the Trias periods. Mr. Edward Hull, the learned director of the Geological Survey of Ireland, has made researches in the same field, but on a more limited area. Mr. Hull has given a series of very interesting paleo-geological and geographical maps of the British Islands and the adjoining parts of the continent of Europe. And finally, the important memoir of Director A. Karpinski of the Geological Survey of Russia, on the physical geography in geological times of Russia in Europe, should be mentioned. I shall say only a few words in regard to the theory put forward many years ago, of the permanency of the continents and oceans, which is still advocated by a few geologists, †—generally only theroists—and which is strongly supported by zoologists. Partisans or adversaries of the evolution of species want the permanence of the continents and oceans, to sustain their views, however conflicting they may be, and they do not hesitate to maintain as a creed that with slight changes only the oceans and the *terra firma* have always presented the same geographical distribution as now. It is simply a wrong generalization from the facts, which every practical geologist readily accepts: that is to say, that some part of the *terra firma* has al-

†Professor James Geikie in a paper entitled: "The evolution of climate," with maps, just issued as a reprint from the *Scottish Geographical Magazine for February, 1890,* says at p. 21: "But, although the boundaries of the land masses shown upon the maps referred to are thus confessedly provisional, the maps nevertheless bring out the main fact of a gradual growth and consolidation of the land-areas—a passage from insular to continental conditions. I need hardly say this is no novel idea. It was clearly set forth by professor Dana upwards of forty years ago (*Silliman's Journal*, 1846, p. 352; 1847, pp. 176, 381), and it received some years later further illustration from professor Guyot, who insisted upon the *insular* character of the climate during paleozoic times (*The Earth and Man, 1850*)."

The idea of a gradual growth of the land-areas—a passage from insular to continental conditions did not originate with professor Dana or professor Guyot, who only applied it many years after its publication, in France, by Elie de Beaumont, who is the true originator of the idea. Elie de Beaumont was in the habit of showing such maps and used them, in his lectures on practical geology, at both the College de France and the School of Mines in Paris, as far back as 1836. Professor Beudant, with the permission of Elie de Beaumont, has published three of those maps for the Jurassic, Cretaceous and Tertiary seas in his *Cours Elementaire de Geologie* pp. 237, 241, and 243, 1841: and professor Carl Vogt in his *Lehrbuch de Geologie und Petrefactenkunde*, 1845, based entirely on the lectures of Elie de Beaumont during 1844-46, as he expressly says in his introduction, gives at the end of his manual, four large maps of the Carboniferous, Jurassic, Cretaceous and Tertiary seas. So the "novel idea" is due to Elie de Beaumont; and its publication was made first by Beudant in 1841, and afterward by Carl Vogt in 1845, several years before Dana's and Guyot's publications.

ways been dry land and was never covered by salt water and consequently by sedimentary marine deposits. The number of such areas is very limited, and more so than appears from a first glimpse at the "Geological Map of the World"; for dislocations on an enormous scale have brought to light great masses of crystalline rocks which were concealed under strata during certain periods of the earth's history; it is not safe, for instance, to conclude from the existence of the great masses of crystalline rocks of the Alps, or Himalaya, or Rocky mountains, that those regions were always out of the seas and formed dry lands. Structural and orographic geology must be always consulted and applied, before reaching conclusions. And any one who has studied carefully any part of the earth, where crystalline rocks exist, would hesitate more than once, before saying such part of the crystalline or primitive rocks has been and remained out of the reach of sea water, and has never been covered by sediments of any sort, except from the aerial decomposition of the crystalline rocks. That such areas exist, it is certain, among the great masses of primitive rocks which cover great surfaces; such, for instance, as the great Scandinavian peninsula and its adjunct Finland, and also some parts of Labrador and even New England. But they are only isolated patches scattered, without connection, all over the actual land areas of the world.

As to permanency of the oceans, it is also true that some spots have remained constantly under sea water, and as the seas cover two-thirds of the earth's surface, it must be expected that isolated patches of permanent sea covering, should be more numerous and larger than the patches of permanent dry land. One thing is certain, that not one of those patches is large enough to form a sea, though very limited, like the White sea or the Baltic sea; and no patches of land of the primitive outcrops constitute now a continent such as Australia, or even an island as large as New Zealand, Celebes, or England.

To try a reconstruction of the land and sea during the Taconic period is an extremely difficult task; because the more we descend into remote age in the geological chronology, the more we are reduced to fragmentary and scattered documents not easy to decipher. It is very bold in me to present such an essay, but I hope it will be regarded as a most informal sketch, extremely crude and rather too hypothetical, but after all an attempt at co-

ordination of facts scattered over one-half the northern hemisphere and which need some sort of bond to consolidate what has already been acquired, by the isolated efforts of fifty or more practical geologists from St. Petersburg to Prague, Madrid, St. David, St. Johns, Cambridge, Williamstown and Eureka city.

The Acadio-Russian sea, was bordered on the north by a Taconic continent running from the vicinity of Revel (Esthonia), to Lapland, Scotland, Ireland, Labrador and the northwest territory of the Canada Dominion. On the east, was an extensive peninsula, starting somewhere near St. Petersburg and extending between Scania and the Basin of Bohemia, as far west as Cornwall and French Brittany and probably a little farther west. Then a sort of Mediterranean area covered by the Acadio-Russian sea, connected Bohemia, France, the Iberian peninsula and the island of Sardinia. South of it, the Taconic continent was formed, very likely, by the whole region of the Barbary states, the Great Sahara desert and the Guinea coast. There seems to have been a sea between Africa and South America.

A narrow and very extended isthmus, connected the North Taconic continent with the South Taconic continent, from Labrador, east of the Straits of Belle Isle, descending to Nova Scotia, the White mountains of New England, Boston, eastern Virginia, Georgia, and expanding under the form of a great continent, which occupied the whole region of the West Indies, Central America, Venezuela, Guiana, Columbia, southern Mexico and extending some distance into the actual tropical Pacific ocean.

West of the great isthmus just spoken of, and inclosed on three sides by dry lands, we have the Nevado-Canadian sea, with its opening west and its extension into the Pacific ocean of that time.

All the outcrops of Lower and Middle Taconia with their special faunas, exist in a single band, which can be called the North Neutral Homozoic band of the Taconic period. In it we have in the two seas, three provinces of marine animals for each sea; which seems very distinct and appropriate. Beginning at the east side, we have first (alpha) the Scania-Wales province, comprising all the part of the Acadio-Russian sea, which extends between Russia and England; then (beta) the Asterio-Bohemia province, comprising Bohemia, France, Spain and Sardinia; and finally (delta)

the Newfoundland-Massachusetts province. comprising south-eastern Newfoundland, New Brunswick and Braintree. Each one of these provinces is characterized by special fossils. some passing from one province to another; but so far the common species are very few.

In the Nevado-Canadian sea, we have also three different provinces of marine animals. The (epsilon) Belle Isle strait—Bald mountain province, comprising the straits of Belle Isle, Canada bay the whole Gulf of St. Lawrence region, Quebec, Vermont, eastern New York, and farther south. The primitive and original area of the Taconic system with the Taconic range of mountains and the spot where Dr. Emmons discovered the primordial fauna, are enclosed in that province. The (gamma) Eureka-Utah province, comprises the state of Nevada, the territory of Utah, and the Grand Cañon of the Colorado. Finally the (pi) Castle Mountain province of British Columbia, comprises all the areas north of the preceding province. All these three provinces of the Nevado Canadian sea are connected by similar forms of fossils and also by a few common species.

Until now, we have no indications of the Taconic faunas existing in the Central and Polar Homozoic bands. It is reserved to future discoveries, for to this day no primordial faunitic horizons are known in either the Central Homozoic band, or Polar Homozoic band. Only an indication exists of a primordial fauna in the South Neutral Homozoic band in South America. But when we remember that in 1844, when Dr. Emmous made his first discovery of a special and older fauna, called since primordial by Barrande, absolutely nothing was known of those immense periods of time which, appropriately, he called Taconic, and that in less than half a century, we have already recognized and described more than six hundred marine species, distributed in six provinces of the North Neutral Homozoic band, for only the two oldest parts of the Taconic period—not speaking for the present of the Upper Taconic time—then we may fairly hope a greater extension of our knowledge all over the world during the next half century; and that the first centennial anniversary of Emmons great discovery and Barrande's great creation of the primordial fauna, will be celebrated with materials collected from Cape Horn to the Arctic archipelago, and from Newfoundland to Kamtschatka, Tasmania, the Cape of Good Hope and Central Africa.

and will be sufficient to allow geologists to give then, a first well based generalization on what was our globe zoologically, as well as physically, during those far remote Taconic times.

Cambridge, Mass., March, 1890.

ON THE CHEYENNE SANDSTONE AND THE NEOCOMIAN SHALES OF KANSAS.

By F. W. Cragin, Topeka, Kansas.

[This article was originally prepared as a contribution to the November (1889) meeting of the Kansas Academy of Science, but was afterwards withheld from the Academy's *Transactions* for the purpose of incorporating additional data, and was published in the *Bulletin* of the Washburn College Laboratory, No. 11 (dated March, 1890, but not issued till April 3).

It is believed to be of sufficient interest to entitle it to a wider reading than it can have through the medium of a local *Bulletin*, and it is here reproduced with a few slight changes, but essentially as it was published in the *Bulletin*.]

Resting unconformably upon the fine-grained brick-red deposits of the Triassic of southern Kansas, in parts of Barber, Pratt, Kiowa, and Comanche counties, on the upper drainage of the Medicine Lodge river and on Mule creek, may be seen a stratum of friable, false-bedded, littoral sandstone, attaining locally a thickness of forty feet. It is ordinarily rather coarse-grained, sometimes gravelly; in a few localities exceedingly fine. Its slight but variable coherency imparts to it a rugged relief. Indeed, the outcrop of this rock offers more variety of form and color than that of any other formation in southern Kansas, though its features are on a smaller scale than that seen in the Gypsum Hill Permian of Barber county.

Two or three "Hell's Half Acres," mere skeletons of the original stratum; the "Natural Corral," in the southeast corner of Kiowa county; the "Natural Well," in Comanche county, near Mule creek; Osage Rock, a prominent point of rocks opposite the village of Belvidere; and numerous named and unnamed chimney-rocks, castles, forts, and gulches—some of them gaily decorated with spots and stripes of purple, crimson, scarlet, and brown, but of prevailing yellow, gray, and whitish shades—are characteristic features in the relief of its outcrop.

The dip is to the southeast.

While this sandstone seems to be closely related to the Potomac and Tuscaloosa divisions of the Atlantic states, to the Trinity division of Texas and Arkansas, and to the Atlantosaurus beds of Wyoming and Colorado, it would be premature to assert positively,

at this time, the precise identity of any two of these. Incomplete geographic and stratigraphic data suggest a probability that the above described sandstone represents a portion of the Trinity division; but reference of it to the Trinity division in any way, until the Indian Territory interval has been explored, is of course merely a supposition, however probable.

The fauna of the Trinity division, according to Prof. Hill, is Purbeck-Wealden in its affinities, but according to Prof. Marcou, it is referable to the upper Jurassic. That of the sandstone under consideration is wholly unknown. The one genus known to belong to the flora of the latter, ranges from the Purbeck to the upper Neocomian, but the species is most like those of the Purbeck.

In default of precise knowledge as to the stratigraphic and palæontologic equivalency of this sandstone, it will be expedient to know it, for the present, by a local name. I designate it, therefore, as the Cheyenne sandstone. This name was suggested (see *Bul. Washburn Coll. Lab. Nat. Hist.*, No. 11, p. 70) in allusion to the prominent point of rocks above mentioned as "Osage Rock," which has been called by some, "the Cheyenne Rock," and which belongs to the stratum under discussion, is easily accessible by way of the Melvane Extension of the C. K. & W. Railway, and boasts historical prestige as an Indian battle-ground. It appears, however, that the name, "Osage Rock," is now far more generally used, the Osages having been the victors in the latest battle. The name "Cheyenne," so far as based upon the supposed name of the Belvidere point of rocks, is therefore not the most appropriate. But as it was proposed for a temporary purpose only and is probably destined to become a synonym, it seems needless to change it; and I would here propose it anew, in allusion to the fact that the Cheyenne Indians frequently ranged over the district in which this sandstone occurs.

The only fossils of the Cheyenne sandstone thus far discovered are closely related to those of the "Purbeck Dirt-beds" of England, the most important being a portion of the stump of a cycad of the genus *Cycadoidea* (*Mantellia*). The species, which is apparently distinct from any of the several known forms from the old world upper Jurassic and lower Cretaceous, was described in December, 1889, in the *Bulletin* of the Washburn College Laboratory of Natural History (Vol II., p. 65)† under the name,

†"Contributions to the Palæontology of the Plains.—No. 1."

Cycadoidea munita. The type-specimen indicates a stump a foot in diameter and of about the same or a little greater hight, and of broadly ovate outline in side-view. The false-bark, which seems to have been more or less readily separable from the wood, had a thickness of 3.25 to 3.75 inches in the region of greatest horizontal diameter of the stump, diminishing to 2.25 inches or less in the upper portion. The rhomboidal markings on the exterior of the false-bark measured 1 to 1.5 inches by .6 to .8 inch (for the most part about 1.25 inches for the horizontal dimension). The species is thus intermediate in its characters between *C. megalophylla* and *C. microphylla.* For an account of the character of the inner portion of the leaf-stalk, and for other details, the above-cited reference may be consulted.

The Maryland cycad announced by Mr. T. P. Tyson in 1860‡ was, as I am informed, taken from the formation now known as the Potomac Division. A photograph, for the use of which I am indebted to Mr. Jules Marcou, representing this cycad with an extended two-foot rule beside it, and thus providing for accurate comparison with the Kansas specimen, indicates§ the probable specific identity of the Potomac cycad with the latter.

Occurring abundantly in the Cheyenne sandstone are silicified logs belonging to trees of the coniferous sort, but of genera as yet undetermined. They are presumably allied to those which are associated with *Cycadoidea* in the Purbeck and Neocomian of England. One of these logs was traced by the writer from the loose sand of a ravine into the solid sandstone and for a length of forty-five feet, which included neither stump nor tree-top, the smaller end having a thickness of thirteen inches. It is to this sandstone that the ordinary petrified logs seen in door-yards, and in use sometimes as hitching-posts in the Sun City and Belvidere district, belong.

Seams of lignite and fragments of soft, charcoal-like, bituminized wood occur in the Cheyenne sandstone in some localities. Careful study of these may lead to further light on the plant-life of Kansas in Jura-cretacic times.

The false-bedded structure, the drifted logs and cycads, and the bands of lignite all testify that this sandstone was deposited in littoral waters.

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‡First Report of Maryland, page 42, January, 1860.

§See *Bul.* Washb. Coll. Lab. Nat. Hist. No. 10, p. 66.

The Cheyenne sandstone is for the most part overlaid with the Neocomian shales, or immediately with the shell-conglomerate (No. 5 of Belvidere section); but in a few localities the shales and more or less of the sandstone itself have been eroded, so that what remains is covered with fluviatile Quaternary and recent talus deposits. On some of the valley slopes of Soldier creek, near the east line of Kiowa county, ledges of Cheyenne sandstone may be seen overlaid with calcareous marl, sand, and gravel. That the latter is disintegrated Loup Fork conglomerate, is shown by the traces of incrustation with characteristic Loup Fork cement. In the Comanche county "Natural Well" above-mentioned, the Cheyenne stratum forms a considerable part of the wall and is found beneath recent alluvial.

Of the extent of the Cheyenne division beyond the limits of the four counties above mentioned, little can now be said, aside from speculations as to its equivalency to the Potomac and Trinity divisions. It seems to be lacking in Clark county, where Neocomian shell-conglomerates and shales, similar to those which overlie the Cheyenne sandstone on the Medicine Lodge river, rest directly upon the Red-beds. It probably reached at least as far east as the west line of Harper county originally, near which line, though in Barber county, fragments of the fossils of this sandstone and of the more recent Neocomian shell-conglomerates occur as inclusions in the Loup Fork Tertiary conglomerate. Certain sandstones and mottled white and deep purple-red clays, associated with the black shale and lignite, resting upon the Permian, and overlaid by strata containing characteristic fossils of No. 3 of the Belvidere section, which outcrop on the western border of McPherson county, near Windom, are probably the equivalents of Cheyenne sandstone in that region.

I first examined the Cheyenne sandstone about the first of January, 1885, and partially described it in April of the same year in my "Notes on the Geology of Southern Kansas" (*Bul.* Wash. Coll. Lab. Nat. Hist. No. 3, p. 90),* but I at that time quite

*The following is the description referred to, in connection with a still briefer description of the shales discussed in the latter part of the present paper; it is of interest as that of one of the remarkable color-displays so common in the Cheyenne sandstone and as the earliest printed reference to the leading features of the Cheyenne and Comanche divisions in Kansas: "A locality a few miles southwest of Sun City, locally known as the 'Black Hill,' affords an easily recognized horizon for reference in any studies that may be made of the neighboring formations,

misunderstood the stratigraphic relations of that region, and referred this sandstone to the Benton. It was subsequently visited by Mr. Robert Hay, who referred it to the Dakota (Tran. Kan. Ac. Sci. X, 22). Still later, it was reconnoitered by Prof. Orestes St. John, who likewise referred it to the Dakota (Fifth Bienn. Rep. Kan. State Bd. Agr., Part II, p. 143). Since the fall of 1884, I have had frequent opportunity of studying the region in which the Cheyenne division occurs, and some preliminary results of that study were published in No. 9 of the Washburn College *Bulletin*, under the title "Geological Notes on the region south of the Great Bend of the Arkansas River." In that article (p. 35) I have briefly redescribed the Cheyenne sandstone and placed it, in my Belvidere section, at the base of a series of shales which I provisionally referred to the Comanche series. Though at that writing I suspected its identity with the Dinosaur sand (later called Trinity division) of Prof. Hill, I contented myself with pointing out the probable age of the overlying shales and giving a section showing the relations of the sandstone to the latter. On receiving my paper, Prof. Hill expressed his belief that the sandstone in question was probably referable to his Trinity division (Ann. Rep. Ark. Geol. Surv. for 1888, II, 115). The data which the writer has acquired touching the Cheyenne sandstone tend to confirm this opinion and the suggestion also made by Prof. Hill (*op, cit.*, p. 179) that the Trinity division is allied to the Potomac. Indeed, if the Cheyenne sandstone be referred to the Trinity division, the discovery of Purbeckian cycads in the Cheyenne, in connection with the previously reported occurrence of the same in the Potomac, adds a strong link to the chain of evidence associating the Trinity division with the Potomac.

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being well up above the gypsum, conspicuous, and quite unique. It may be designated as the 'Black Hill horizon.' The deposit from which the hill takes its name is a bed of carbonaceous and rapidly decomposing shale.

"In connection with the shale are found fragmentary seams of poor lignite. Immediately above and below this is a layer of shell-conglomerate, madeup largely of *Ostrea* and *Gryphæa*. Below these is a formation quite unlike any other I have seen or heard of in Kansas, and well worth a visit to the place to see. It is a variegated sandstone, unfortunately too friable for utility, but displaying a most beautiful variety of colors. Brown, purple, blue, crimson, scarlet, pink, orange, lemon-yellow, and white, these and many intermediate shades may be seen, in brightest contrasts and most delicate blendings. Streaked and interstreaked in a tortuous manner, clouded and blended, blotched and blurred, the dispositions of the colors are as endless as their shades."

If we assume that the Cheyenne sandstone is referable to the Trinity division, it is remarkable that *Ostrea franklini* should be widely characteristic of and, so far as now known, confined to the latter division in Texas and Arkansas, while in Kansas it is lacking in the same, but characteristic of the Neocomian series.

It thus appears that *Ostrea franklini* is common to the Trinity of Texas and the Neocomian of Kansas; and if, as claimed by Marcou,* the European analogue of *Ostrea franklini* is *O. acuminata* of the Kimmeridge, it is not easy to see how the *O. franklini* has any weight in determiming whether the Trinity division be more nearly related to the upper Jurassic or to the lower Cretaceous. The same difficulty remains if *Ostrea dubiensis* of the Montbeliard Kimmeridge be considered, with Hill‡, the European form of *O. franklini*. *Pleurocera strombiformis* being common to both Purbeck and Wealden (*fide* Hill), is likewise unavailable as a criterion. If the fact that the only known Upper Neocomian† *Cycadoidea* (*C. inclus*, Carr) is a small species, conclusively indicated that the forms of this genus underwent a gradual diminution in size from the Purbeckian through Neocomian time, the large size of the Kansas and Maryland specimens would seem to refer them to the upper Jurassic. But there remains a geographical explanation of the small size of *C. inclusa*, which is at least plausible, not to mention the alleged inferiority of data from botany, as contrasted with those from marine invertebrate zoology as chronologic criteria.

The estuarine sediments at the base of the American Cretaceous can, therefore, hardly be referred to the Purbeck or to the Wealden with perfect satisfaction as yet, and are probably best considered, for the present, as transition rocks, or Jura-cretacic.

[TO BE CONTINUED.]

COAL MEASURES OF THE INDIAN TERRITORY.

By DR. H M. CHANCE, Philadelphia.

The writer has already published a paper descriptive of the general features of the Indian Territory Coal Measures under the title of "Geology of the Choctaw Coalfield" in the Transactions of

*AMERICAN GEOLOGIST, Dec., 1889, p. 361.
‡Ann. Rep. Geol. Surv. Ark. for 1888. II, 131 and 132.
†Prestwich. Geology: Chemical, Physical, and Stratigraphical, Vol. II, p. 270.

the American Institute of Mining Engineers, February, 1890, and here desires only to describe more particularly the discovery of the unexpected and extraordinary thickness of coal-bearing rocks, which is stated in the above mentioned paper are at least 8,500 and possibly 10,000 feet thick.

During the winter of 1889 Mr. R. H. Sanders made a flying visit to the McAlester district on the line of the M. K. and T. railroad, and upon returning to Philadelphia informed me that the Coal Measures present in that (McAlester) basin were certainly 3,000 feet or more thick. Upon arriving on the ground in the spring of 1889 I was therefore prepared to find Coal Measures about equal in thickness to those of our Appalachian fields. Commencing exploratory work in the McAlester basin I soon became convinced that Mr. Sanders' estimate was substantially correct, but to his measurements I had subsequently to add somewhat more than 1,000 feet for measures not coming to the surface at McAlester and which underlie the McAlester coal bed.

The explorations were made for the Choctaw Coal and Railway company, then partially organized, the officials of which with commendable generosity have permitted publication of the results; which in similar cases are too often jealously guarded as private information too valuable to be given gratuitously to the public.

Continuing the explorations eastward from the McAlester field towards Arkansas, by tracing the Grady (lowest) and McAlester series of Coals, I was astonished to find a great mass of rocks also coal-bearing and lithologically quite similar, coming in above the McAlester basin series and evidently conformable to, and a virtual upward extension of, the series, making a total thickness of 8,500 to 10,000 feet. Unfortunately the time and facilities for careful study and accurate measurement could not be had, and I was forced to be content with an estimate made by calculation from distances measured by an odometer attached to a "buckboard" wagon.

This great mass of coal-bearing rocks is found in the Kavanaugh (or Cavanal or Cavaniol or Cavanaugh) mountains 15 to 30 miles west of the Arkansas state line and north and west of the St. Louis and San Francisco railroad.

Starting at Bryan station on that railroad where the Grady (lowest) coal is opened and worked, and passing almost due north to and across the Kavanaugh mountains, a distance of five or six

miles, the whole series is crossed, and an accurately surveyed line here would give the data for a cross-section showing its true thickness. The dip is constantly to the north, being about 40 degrees at the Bryan mine and gradually decreasing until the formation is flat under the centre or backbone of the Kavanaugh range.

Doubtless the results of Mr. Winslow and his successor in the Arkansas fields will show the existence of nearly the same thickness, for I believe the Poteau and Sugarloaf mountains on the Arkansas line are geologically the equivalents of the Kavanaugh range in the Choctaw country.

In a general way the formation is divisible into an upper and a lower coal-bearing or "productive" series, each carrying workable beds of coal,—that is, beds from 3 to 5 feet thick,—with an intervening "barren" series in which no large beds of coal have yet been found. These are possibly the same with Mr. Winslows' provisional "upper" and "lower" series in his preliminary report for 1888,* but the thickness assigned his "lower" series is but a few hundred feet while the "lower" series in the Choctaw country is over 3,000 feet, which difference may prove to be merely one of classification.

Possibly the work of the Texas survey may disclose the presence of a similar development.

While I have no palæontological evidence of the Coal Measure age of the whole series (and possibly the upper portion may prove of Permian age), from the lithological and stratigraphical features of the formation I am inclined to think the whole series belongs to the true Carboniferous,—that the lowest coals are not "Subcarboniferous" nor the upper beds Permian.

In the presence of such an unusual thickness of coal-bearing rocks and the absence of complete surveys of the formation in adjacent states, it seems useless to attempt correlation except perhaps with the Arkansas coals, which has already been indicated.

GLACIATION OF EASTERN CANADA.

By ROBERT CHALMERS, Ottawa, Canada.
Of the Canadian Geological Survey.

A paper on the Glaciation of Eastern Canada by the writer appeared in the April No. of the Canadian *Record of Science*, Montreal. It was intended to be a condensed statement of the

*Geol. Sur. of Ark. Vol. III, Annual Report for 1888—published in 1889.

principal facts hitherto collected on this interesting subject, with references to the reports and publications in which details are given. The following is an abstract which I send to the GEOLOGIST. The subject is regarded as an important one, and has occupied the attention of geologists for many years, as eastern Canada is the battle ground, so to speak, of the advocates of the rival theories of continental glaciation and floating ice. The results thus far obtained from a somewhat careful study of its glacial phenomena, however, point to conclusions which are at variance with those held by extreme glacialists, and show that the theory of local glaciers upon the more elevated portions of the country and icebergs or floating ice striating the lower costal areas during the Post-Tertiary submergence of these, as maintained by Sir William Dawson, will serve to explain all the observed phenomena. The term 'local glacier' I define as an ice-sheet limited in extent, that is, confined to one valley or hydrographic basin, whether large or small, and influenced in its movements by local topographic features, such as mountains, water-sheds, hills, or the valleys of the larger rivers. The data have been collected chiefly by the staff of the geological survey; but Sir William Dawson, who has long studied this region, and others have done much valuable work in glacial geology here.

In reference to the origin and movements of local glaciers, it may be stated, that the main facts pertaining to each centre of dispersion, when correlated, show that these glaciers were independent bodies which had large gathering-grounds upon the higher parts of the country where snow fields and *névé* must have existed. Whenever motion began this snow and *névé* became converted into glacier-ice. Upon areas where they never underwent change into ice no striation of the rocks took place. In their movements the glaciers, generally speaking, followed the slopes of the land or the present drainage channels. Some of them seem to have been quite large, and those from adjacent drainage areas may have coalesced on the lower grounds and become confluent. At all events, the slopes and costal tracts are usually more glaciated than the interior and higher grounds.

In Nova Scotia there was a shedding of ice from the Cobequid mountains northward and southward, and the South mountain appears also to have sent glaciers down its slopes, on either side. Sir William Dawson, Dr. Honeyman, Mr. H. Fletcher, Dr. R. W.

Ells, and others have made numerous observations showing many divergent courses of striæ, which are explicable only on the theory of local glaciers and icebergs.

The main water-shed of New Brunswick, which traverses the province from north-west to south-east, sent off glaciers in nearly opposite directions, or north-eastward towards the bay Des Chaleurs and gulf of St. Lawrence on the northern slope, and south-eastward towards the bay of Fundy on the southern slope. This is abundantly proved by data collected by the writer and others.[1]

Considerable areas in the interior of this province, where centres of dispersion for local glaciers existed, are unglaciated, no ice-action whatever nor boulder-clay being seen, and the loose materials consisting largely of rock debris *in situ*. These were probably snow-fields and gathering grounds for the ice during the glacial period. The glaciers on the southern slope appear to have been much larger than on the northern. But even upon the former they had numerous local and divergent movements, as the evidence shows.

The Shickshock or Notre Dame mountains in south-eastern Quebec and their continuation south-westward had also large gathering grounds for snow and ice on their summits and shed glaciers south-eastward into the bay Des Chaleurs and the valleys of the Restigouche and St. John rivers, and north-westward into the St. Lawrence valley, the estuarine portion of which must then have been open to receive them.[2] The valleys of tributary rivers and the subordinate ridges and hills caused, however, many local deflections in the ice-currents.

The glacial phenomena of the Archean area north of the St. Lawrence and great lakes have also been investigated to some extent. The general parallelism of the Laurentian slope, north of the St. Lawrence, to that of the Notre Dame range on the south side caused the striæ observed on it to have nearly the same course as those on both slopes of the latter, the ice flowing down these slopes at about right angles to the main axes of the mountains.[3] This fact has been made use of to support the theory of a massive

[1]Annual Report, Geol. Surv. Canada, 1885, vol. I. part GG.

[2]Annual Report, Geol. Surv. Canada, 1886, parts I. and M.

[3]Geology of Canada, 1863, pp. 890-92; Notes on the Post-Pliocene Geology of Canada, 'Canadian Naturalist,' 1872; Annual Report, Geol. Surv. Canada, 1886, parts I. and M.

ice-sheet moving from the Laurentides across the St. Lawrence valley over the summits of the Appalachians and down the New England slope to the Atlantic. But it appears the evidence at hand does not support this view. The Archean area has, however, sent sheets of ice down its slopes in all directions around its circumference. In the central part, on the east side of the Hudson bay, they moved directly westward into its basin. In Hudson strait, according to Bell, the ice had a northeastward and eastward flow. Whether the whole Archean area was covered by glaciers flowing outwardly from the centre towards the circumference, or with snow fields forming the *névé* of local glaciers, as seems more probable, is a question to be decided by future investigation. Areas of unglaciated rock surface, doubtless, occur there as well as upon other elevated portions of eastern Canada where decomposed rock lies undisturbed except from subaerial action.

The extent and thickness of the glaciers cannot as yet be satisfactorily determined; but they seem to have been largest on the southern slopes of the Appalachians and Laurentides. The cause of this is not evident; but as regards those of the first mentioned mountains, which are in a part of the country with which the writer is most familiar, it may be owing in some measure at least to the difference in the steepness of the slopes on either side of it. The south-east slope is long, much broken, and has numerous comparatively level areas upon it. As the rate of motion would be slower on this slope, the ice would necessarily accumulate in larger sheets in depressions and on the level tracts. On the shorter and steeper slope of the St. Lawrence the motion of the ice would be more rapid, and it would more readily debouch into the estuary or sea.

Evidences of the action of icebergs or floating ice are found in the St. Lawrence valley and on the bay Des Chaleurs coast, also in a number of other places around the shores of the gulf of St. Lawrence. So far as the writer has observed, they are met with only on ledges below the 200 to 350 feet contour-line above sea-level. Floating ice seems to have played an important part in transporting boulders over the submerged areas.

The views here briefly outlined will doubtless undergo some modification, when this region, especially that part of it known as the great Archean area, comes to be studied in greater detail.

I think, however, the main conclusions herein advanced will stand.

Newfoundland, although not forming part of Canada, is geographically connected with it, and its glacial phenomena may therefore be referred to here. The late Alex. Murray, C.M.G., Director of the Geological Survey for many years, states that its surface is everywhere glaciated.[2] He held the theory of a continental ice-sheet, however; but his facts show that the striæ are quite divergent, following depressions and valleys in different directions. It seems probable, therefore, that here, as in eastern Canada, local glaciers produced the chief striation observed, as pointed out by the late captain Kerr, R. N.[1] But from its insular position and lying as it does in the track of the arctic currents, the coast areas must have been intensely eroded from icebergs and floating ice.

EDITORIAL COMMENT.

Snow Hall of Natural History at Lawrence, Kansas.

In 1885 the Legislature of the State of Kansas appropriated the sum of $50,000 for the erection of a suitable building for the natural history department of the State University. The building was completed in the autumn of 1886 and named for Prof. F. H. Snow, who had been connected with the university from its beginning and under whose direction numerous and valuable collections in every department of natural history, had been made.

Snow Hall is two stories high with basement and attic. It is partially divided from top to bottom by halls, and stairways, into two parts. The portion thus set off to the west of the main entrance is devoted to purposes of exhibition, and the opposite portion to instruction. On the east side are lecture rooms, laboratories and work rooms with special cabinets. The main lecture room is a large room with ceiling 30 feet high, and is capable of seating

[2]Transactions of the Roy. Soc. of Canada, 1882, sec. iv., paper on the Glaciation of Newfoundland.

[1]Trans. of the Roy. Soc. of Canada, 1882, Sec. iv., paper on the Glaciation of Newfoundland, p. 68.

nearly 300 persons. The seats rise gradually from the basement to the first floor. On the west side are four large rooms, one above the other, with dimensions 86x36 ft.: the lowest one is used for laboratory work, the two middle ones for public museum rooms, and the fourth one in the attic for storage purposes.

The first floor is devoted to geology. The spacious museum room contains the large Cooper collection of minerals; and a most unique and valuable collection of Dakota sandstone fossil leaves, made by judge E. P. West. Fossil shells of all kinds, immense saurians, horses, sharks and a life size cast of Megatherium cuvieri also find a place here.

The collection of vertebrate fossils from the Niobrara section of the Cretaceous formation in western Kansas, is pronounced by Dr. Geo. Baur to be the finest collection on exhibition in either Europe or America. This collection contains many remarkable saurians, fishes and birds including a Mososaur with the dermal scales in perfect preservation. The latter specimen was discovered by Prof. Snow in 1878, and has never been duplicated. Another unique specimen is the fossil feather of a Cretaceous bird, discovered last summer by judge West, and the only bird feather yet found in America below the Tertiary.

Prof. S. W. Williston, professor of anatomy in Yale Medical School has accepted the chair of geology, and will begin service September 1st. Professor Williston was for years professor Marsh's right hand man, and is also the most eminent authority on *Diptera* in the country.

All work in Zoology and Botany is done on the 2d floor. Professor Snow, while the chancellor of the university, is still director of the museum, and has a supervision over all departments. His specialty has been entomology, especially from an economic standpoint, and the university possesses the largest collection of insects to be found in any American college with the exception of the one at Cambridge. V. L. Kellogg is the assistant in entomology. He is a graduate of the department and has contributed to scientific knowledge by his observations on the *Mallophage.*

Work in botany is directed by Mr. W. C. Stevens, also a graduate of the University of Kansas. He is aided by a large herbarium of North American plants, collected by professor Snow.

Prof. L. L. Dyche, in the chair of Anatomy and Zoology, has built up a magnificent collection of American birds and mammals. He is said to be the most accurate taxidermist in the country; and his striking groups of grizzly bears, mountain lions, Rocky Mountain sheep and goats, and buffalo are evidence of his skill. Professor Dyche shoots nearly all the animals he mounts, spending most of his vacations in the field. He is now preparing for his second trip to northern British America, to hunt moose and caribou. He is assisted by Miss Gertrude Crotty in anatomy, and by E. D. Eames in taxidermy.

The rooms of Snow Hall are heated by steam, the "indirect" method being employed to furnish the rooms with fresh air, and the direct method for securing proper temperature.

Fresh air is introduced into the building by means of a "plenum" extending under the entire building and connecting with the outer air by arched openings and areas. Ventilation is accomplished by means of large flues leading from floor to ceiling of all rooms, to a large iron chamber in the attic, in which sufficient radiation is located to secure a sucessful movement of the foul air through a ventilating cupola to the exterior.

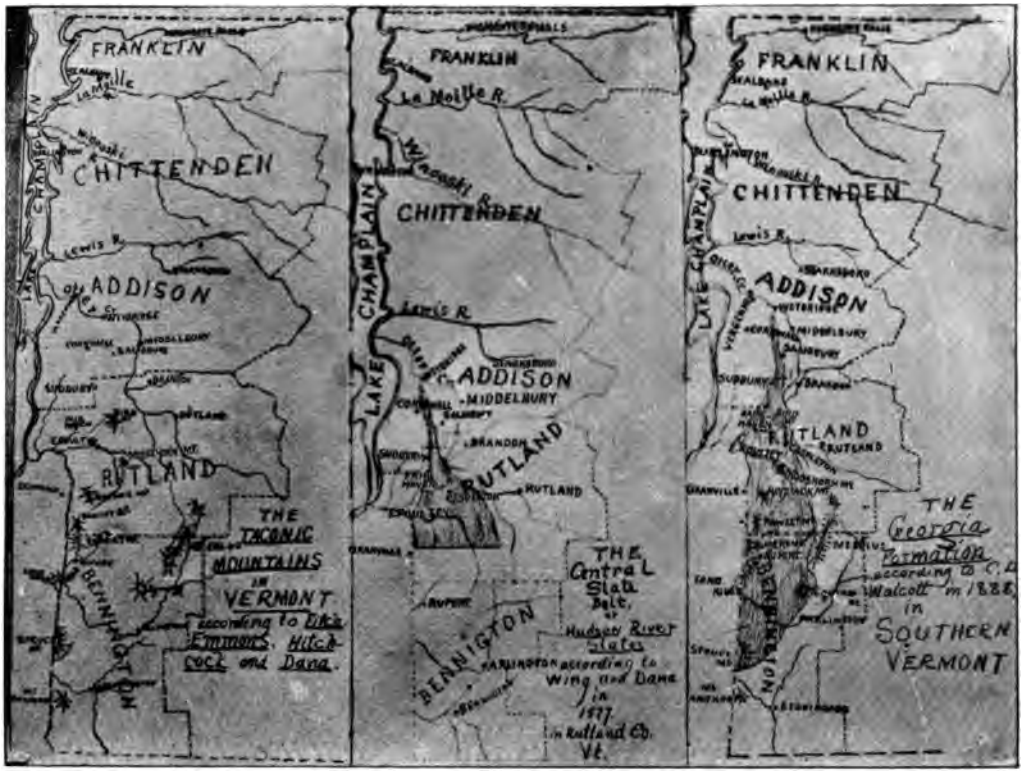
Plenty of light even on cloudy days, is secured by the large, well arranged windows. The museum rooms are lighted on three sides, and opposite the center of the unlighted side of each of these rooms, a large plate glass window eight feet wide and eleven feet high helps to diffuse a proper amount of light all over the room.

The building is rendered nearly fire proof by use of iron girders, floors deadened with mortar on corrugated iron, wire lathing, polished hard wood finish, and slate and stone exterior. And in addition to prevention secured by construction, improved appliances for curing a conflagration hang on every floor.

The stone used in this building is the white limestone from the Cottonwood Falls (Kansas) quarries, and this rock is wrought into handsome carvings over the buttressed front.

Work in this beautiful building is being prosecuted under most favorable circumstances. The department has been treated generously in the matter of appropriations and has been able to secure the best appliances and able instructors.

SNOW HALL OF NATURAL HISTORY, UNIVERSITY OF KANSAS, LAWRENCE.



THE TACONIC MOUNTAINS IN VERMONT.

WHAT CONSTITUTES THE TACONIC RANGE OF MOUNTAINS.

Dr. Asa Fitch describes the Taconic mountains in the following words: Runs along the east line of this county, immediately on the Vermont side of that line. From Mt. Anthony in Bennington, it passes through Spruce (or West) mountain, Red, Equinox Bear, Antonio, Rupert and Pawlet (two names given to one long mountain) to Haystack, east of Granville village. (HISTORICAL, TOPOGRAPHICAL AND AGRICULTURAL SURVEY OF THE COUNTY OF WASHINGTON, 1849, p. 936.)

Prof. J. D. Dana describes the Taconic range of mountains in the following words, so far as they exist in Vermont: This great slate belt extends from Weybridge on the north to the southwestern corner of the state, widening southward and spreading into the state of New York. The part south of Brandon has been called the Taconic range of mountains, it being properly a continuation of the Taconic range of Massachusetts. [*Am. Jour. Sci.* (3) XIII. 336, 1877.]

Geologically these hills consist, according to Mr. C. D. Walcott's geological map of the Taconic region, of "Cambrian" formations, *i. e.* of Taconic or primordial strata. [See his map accompanying his papers on THE TACONIC SYSTEM OF EMMONS AND THE USE OF THE NAME TACONIC IN GEOLOGIC NOMENCLATURE. *Am. Jour. Sci.* (3) XXXV.] He also says: Fossils occur more or less abundantly at over 100 localities as now known to me within the typical Taconic area, and they are distributed at various horizons throughout the 14,000 feet or more of strata referred to this terrane. [*Am. Jour. Sci.* (3) XXXV. 242.]

This is a direct and complete verification of the claims of Dr. Emmons in the establishment of the Taconic system on the rocks of the Taconic mountains.

Thine own mouth condemneth thee and not I: yea, thine own lips testify against thee. Job xv., 6.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

An American Geological Railway Guide, giving the geological formation at every railway station, with altitudes above mean tide-water, notes on interesting places on the routes, and a description of each of the formations. By JAMES MACFARLANE. Second edition, revised and enlarged, edited by JAMES R. MACFARLANE. D. Appleton & Co., 1890. pp. 426.

The first edition of this convenient manual appeared twelve years ago; and at the time of the author's death, in 1885, he had prepared several of the chapters for this second issue, and had published advance sheets of the part relating to the Dominion of Canada. Its completion has been accomplished as a work of filial love by his son, during the fragments of leisure that could be spared from a busy professional life.

The plan of the book is to give the names of the successive railway stations, with their distances in miles from the beginning of the line, and against each to state the geologic formation exposed there, and its hight in feet above the sea. Copious notes also call attention to localities of quarries, mines, oil and gas wells, the best points for collection of fossils and minerals, and views of grand or beautiful scenery.

Introductory tables of the geologic formations, as arranged by Dana and by Hunt, and the general descriptions of the formations, intended for travelers who are not versed in geology, occupy the first fifty pages. In the later parts of the work, under each district, as the Maritime Provinces of Canada, the New England states, New York, etc., the local development of these formations is stated in descending order, with a uniform system of numbering, by which the various regions may be readily compared. A small sketch map of the geology of the United States is given; but a larger geologic map, or more than one, including Canada, folded in a pocket of the cover, would be a useful addition.

Appreciating the practical value of such a compilation, the several state and United States and Canadian geologists have co-operated with the author and editor, supplying detailed information of their respective districts. Not only the bed-rocks, but also the glacial drift, moraines, drumlins, and Quaternary lake-beds, are quite fully noticed. Perhaps the most interesting feature of the book for many tourists will be the figures showing how the profile rises and falls in crossing the watersheds and descending into the valleys. It will be a most valuable hand-book for all geologists and travelers in this country and Canada.

Synopsis of American Carbonic Calyptræidæ, by CHARLES R. KEYES. (Proc. Acad. Nat. Sci., Philada., 1890, p. 150-181.)

This is a complete résumé of all that is at present known concerning the American Carbonic shells hitherto commonly referred to Conrad's

genus Platyceras. There are also incorporated many new observations derived from an exhaustive study of a large number of specimens collected during the past few years; besides an examination of nearly all the types of the different forms. Of a single species more than three hundred specimens were obtained from a single locality for the purpose of determining the limits of variation. Although it is to be regretted that the familiar name established by Conrad nearly half a century ago is to be given up, it is thought that the change will be a great advantage in the consideration of this group, since it has long been regarded, particularly by those palæontologists who are somewhat familiar with recent shells, that Conrad's group actually formed a part of Capulus of Montfort. After a brief review of the nominal history of the group, the habits of the ancient Calyptræus are discussed. This refers chiefly to the attachment of the gasteropod shells to crinoids; and the consequent variation in the form of the shell and range of variability. The descriptions of numerous illustrative examples are given at length. This intimate association of crinoid and gasteropod has been noted in the cases of at least a score of species of the former, and nearly a dozen of the latter. These are given in tabulated form. It must be borne in mind that the close relations of the two forms do not imply that the gasteropod was parasitic in its habits as is generally regarded but that the mollusk, though for a greater part of its life stationary, probably fed only on the excrementitious matter of the crinoid and on the minute organisms brought near by the slowly waving arms of the echinoderm.

The remarks on geographic and geologic distribution have a wide application. The relation of the forms from the Burlington and Keokuk rocks is very significant in its bearing upon the true connection of the two formations. Following the last section is a stratigraphical catalogue of the known forms, a discussion of the generic characters and an enumeration ef the recognized species: of the latter new descriptions are made from the abundant material examined. Each description is accompanied by a full bibliography and a complete discussion of the leading characteristics, peculiarities and other points of interest. Twenty-two species are regarded as valid. The closing section is devoted to brief remarks on the spurious and doubtful species. A plate of twenty-three figures of the most peculiar forms, and species never before figured, accompanies the monograph.

Meteoric Irons. GEORGE F. KUNZ, in the Trans. N. Y. Acad. Sci., Vol. IX, No. 8, May-June, gives some interesting descriptions of various meteorites. In the first paper (pp 186) are described about twenty or more meteorites recently discovered in Brenham twp., Kiowa county, Kansas. The masses range in size from 466 lbs. to 1 lb. and less. Two of these masses (345 lbs. and 75 lbs.) belong to the caillites, the others, containing olivine, to the pallasites. Analyses of the iron gave Fe. 88.49; Ni. 10.35; Co. .57; Sp. gr. 7.93. Mr. Kunz says: "This group of meteorites possesses more than ordinary interest on account both of the peculiar composition and structure, and also of the

undoubted ethnological relation, especially because of the probable connection with the meteoric iron found in the Turner Mounds (Ohio).

The second paper (pp. 194), "Meteoric Iron from Bridgewater, Burke Co., N. C." This mass originally weighed 30 lbs., has a sp. gr. of 6.617 and contains Fe. 88.90; Ni. 9.94; Co. .76; P. .35; Cl. .02. The Widmannstätten figures were developed. The third paper (pp. 196), "Meteoric Iron from Summit, Blount Co., Ala." This mass weighs 2.2 lbs., sp. gr. 6.949, comp., Fe. 93.39; Ni. 5.62; Co. .58; P. .31; contains a large quantity of free chloride of iron. Instead of the Widmannstätten figures there was developed a banded appearance. Fourth paper on "Meteoric Iron from Colfax twp., Rntherford Co., N. C." This is a small mass weighing 72 Troy ounces. Composition very variable, ranging Fe. 87.69 to 89.22; Ni. 11.26 to 9.37; Co. .62 to .53. Fifth paper (p. 198) short description of a stone which fell at Ferguson, Haywood Co., N. C., July 18, 1889.

Sixth paper (p. 201) is a most interesting one on the "Aerolites which fell May 2d, 1890, in Winnebago Co., Iowa." Over 500 pieces of the shower have been recovered; the largest of these weighs 85 lbs; the smallest $\frac{1}{20}$ oz. This meteor is a typical chondrodite, porous, with a sp. gr. of 3.638. According to L. G. Eakins the approximate composition of the mass is: Nickeliferous iron, 19.40; Troilite, 6.19; Silicates soluble in H Cl, 36.04; Silicates insoluble in H Cl, 38.37.

The Crinoidea of the Lower Niagara Limestone at Lockport, N. Y., with new species; by E. N. S. Ringueberg, (Ann. N. Y. Acad. Sci., Vol. V., July, 1890, p. 301).

Notwithstanding the above title no descriptions are given of the various crinoids announced up to the date of this paper, the author confining himself to the descriptions of five new species as follows: Callicrinus acanthinus, Dendocrinus ? nodibranchiatus, Glyptaster lockportensis, Icthyocrinus conoideus and Eucalyptocrinus muralis, all from Lockport, New York. The first proves to be a most interesting as well as a remarkable discovery. The genus has not heretofore been recognized from America, but, according to Wachsmuth, Eucalyptocrinus cornutus Hall, and E. ramifer Roemer should be referred to Callicrinus.

Notes on Radiolaria from the Lower Palæozoic Rocks (Landeilo-Caradoc) of the South of Scotland. By George Jennings Hinde, Ph. D. (Annals and Magazine of Natural History, for July, 1890.)

In the Geologist for July, 1890, p. 68, is a notice of the discovery of Palæozoic radiolarians in Lanarkshire and Peebleshire, Scotland. In the Annals and Magazine of Natural History for the same month, Dr. Hinde publishes an elaborate paper giving descriptions and figures of these ancient radiolarians. The radiolarians are found in beds and nodular masses of chert in strata of Lower Silurian age and adjacent to beds of shale containing Glenkiln graptolites. They are strikingly like the modern forms of this group and may all be readily assigned to orders and sub-orders established by Haeckel in his report on the

chert is interesting from the fact that, from what we know of modern Radiolaria of the Challenger Expedition. Furthermore this Silurian Radiolaria, we may infer that we have in these old chert beds a true deep sea deposit of Palæozoic origin. The paper enumerates twenty-three species distributed among eleven genera.

Notes on the Leaves of Liriodendron. By THEODOR HOLM. (From the Proceedings of the United States National Museum, vol. xiii, 1890, No. 794, pp. 15–35, pl. iv–ix.)

This paper gives the result of a study of the variation of leaves from the living *Liriodendron tulipifera L.* and then takes up the so-called fossil species of Liriodendron and considers that "these ancient American types have shown a liability to variation in the same degree as our recent form." The aim of the paper is very clearly stated on page 16, where the writer says that "The object of these notes is to prove that, as far as is known to the author, there is not a greater difference in the foliage between many of the extinct species of *Liriodendron* than between a series of leaves from a very young tree or from a branch of an older one of our recent species." The article may be regarded as a protest against the undue haste of paleobotanists generally to rush into "species making." Until within a comparatively recent time there was the same passion for "species making" among paleozoologists; but, now with the more careful writers there is a greater effort directed toward the combination of variations of a species than to the description of so-called new species. This great variation in the form of leaves, not only from different trees of the same species but from an individual tree, emphasizes to a geologist the greater value of paleozoology than of paleobotany for the purposes of stratigraphical geology.

The author's use of geological terms shows that he has not so thoroughly mastered the details of that science as those of botany.

Mineral Resources of Michigan. CHARLES D. LAWTON. Robert Smith & Co., State Printers, Lansing, Michigan. 8 vo., pp. 181, 1890.

For mine owners and others directly interested in the actual and probable out-put of the various mines this is a valuable report, giving as it does, an account of the location, size and condition of each of the mines, and a detailed record of the business of each company for the past year. The subject of accidents in mines and means of preventing them has been treated ably by Mr. Lawton in former reports and is mentioned incidentally in this one.

The report contains very few of the facts which a commissioner of Mineral Statistics has such abundant opportunity for observing and collating, facts which would lead to a clearer understanding of the origin of the various ores, and their genetic relationship to the rocks in which they occur. These are questions which can never be too carefully studied, and a few facts observed at each mine, and reported merely as facts, even without any attempt to explain them, might result in throwing great light upon some of these unsettled problems.

The report is an interesting and valuable one; and Michigan sets an example which it would much benefit some of her sister States to follow, in the creation and maintenance of a capable commissioner of mines and mineral statistics.

Annual Report of the Department of Mines, New South Wales, for the Year 1889. Sydney; 1890. This report is a royal octavo, paper bound volume of 253 pages, and is devoted to the mineralogical products and geological structure of the several mining districts of New South Wales. Among the minerals of the region are mentioned gold, coal, petroleum shale, tin, copper, silver and lead, iron, antimony, platinum, bismuth, cobalt and nickel, manganese and zinc, graphite, mica, diamonds.

From some of the interesting tables with which the report abounds we learn that the annual output of coal in New South Wales has increased in value from £603,248 in 1881 to £1,632,848 in 1889; the produce of the gold mines for 1889 was worth £434,070, and the value of all mineral products for 1889, £4,780,365. In 1889 the iron produced amounted in value to only £18,330, while the value of the tin and tin ore foots up £415,171.

CORRESPONDENCE.

EXPLORATION OF THE INDIAN TERRITORY AND THE MEDIAL THIRD OF RED RIVER. In company with Mr. J. S. Stone, and under the patronage of the state geologist of Texas, I have made a very thorough reconnoissance with many accurate sections and locations, in northern Texas and southern Indian Territory from Texarkana westward this season. The problems studied were (1) the westward deflection of the two Cretaceous embayments of the Arkansas-Texas region, and (2) the geology of the interior region upon which the Cretaceous sediments were laid down and from which they were derived. The latter line of investigations has developed much light upon the structure of the Ouachita system of mountains (i. e. the mountains of Arkansas and Indian Territory south of the Arkansas). This system was found to be composed of most complicated folds of Carboniferous rocks east of the Missouri, Kansas and Texas railway, with varying trends from W 20° and to N 40°. From near the above mentioned railroad, at New Boggy depot, west to Tishomingo near the Atchison, Topeka and Santa Fe road, is a suberb ridge of granite forty miles in length interspersed with dykes, and completely cutting through the strike of the Coal Measures, and ending the Fort Smith McAllister coal field. This granite is of many species and highly feldspathic. Resting upon this granite north of Tishomingo, and increasing in area westward is a suberb region of folds of fossiliferous

Silurian limestones and shales, with possibly earlier rocks, constituting the Arbuckle—Wichita mountain system.

These rocks extend north 40° in a series of vertical folds forming low treeless ridges, as far west as the staked plains, the Red, Canadians, Washita and Arkansas rivers all being influenced by this trend between the 97th and 100 meridians.

The folding and great denudation of the whole region are remarkable, the whole series from supposed Permian to the base of the Silurian occurring mostly in vertical stratification. There are clearly three great trends throughout the region, (1) a trend from northeast to southwest, as seen in the Kiamitia and Stringtown mountains, which, west of the Tishomingo granite area in the Silurian area is succeeded by (2) a northwest trend, and (3) a later trend of E. 20° N. which has clearly dislocated the former and older trends as shown by the remarkable S shaped dislocations visible all the distance across the Nation. Concerning the age of these trends, it is clear that they have taken place in part since late Carboniferous time, as the rocks of that period are involved in each. I do not mean to say, however, that earlier folding may not have occurred in the Silurian rocks. It is also evident that great disturbance has taken place even in post-Cretacic times, for the Red river flows in a fault through Upper and Lower Cretacic rocks north of Denison with a northern downthrow of nearly a thousand feet. No upland drift material was found, although Red river has cut down 50 feet below its ancient Quaternary river sediments. I hope to present these results more fully at an early day. R. T. HILL.

THE TEXAS CRETACEOUS. In your last number there was a kind notice of my "Check List of the Cretaceous Fossils of Texas." The concluding sentence may be misleading, however. It reads as follows: "The list proves evidently that all the Cretaceous strata in Texas are "more recent than the English Gault." The object of preparing this list was to show for the first time the stratigraphy of the numerous supposed Cretaceous species, and to show their faunal associates in order that the world could have some bases for comparison. No where in the list do I commit myself to an opinion, as to European equivalency for I become more and more, each year, indisposed to correlate our Texan strata with those of Europe alone. I do believe in trans-oceanic correlation, when trans-oceanic faunas are the same, but, it has been utterly impossible heretofore to even have a basis of comparison, without such a list as I have endeavored to give.

I do believe that the Texas alleged Cretaceous strata contain forms which in Europe are characteristic not only of the Gault, the Neocomian, the Wealdan, but of the Jurassic, but the stratigraphy must be studied and unravelled before they can be discussed.

This is now my fifth consecutive month of field study this year upon the Texas Cretaceous strata north of the Colorado river, and notwithstanding my years of previous labor, every day yields some new and important light. How then can we correlate and locate these marvelous beds with European strata?

I have been preparing for several years, however, a paper on the "Paleontologic Position of the North American Cretaceous," which I hope to finish (d. v.) in time for the International Congress provided I am permitted to present it, in which I will try to correctly present the facts.

Very truly yours,

Austin, Texas, Aug. 15, 1890. ROB'T T. HILL.

THE WETWOODS. Between Louisville, Ky., and old Deposit Station, on the line of the Louisville and Nashville R. R. there is an extensive basin lying at the foot of the Knobs, known as "The Wetwoods." It has been noted not only for its wetness, but for the lawless character of its inhabitants. A system of drainage, however, has not only improved the land, but the morals of the people, and one may now pass through it in safety, although the old lawless spirit will show itself occasionally in deeds of murder and violence. During a residence of five years in Louisville I have taken many a weary journey through that section of country trying to solve the problem of its origin. At first it seemed as if the great continental ice-sheet, or spurs of it, must have scooped out the basin in question, and also rounded out the adjoining knobs into their peculiar contour, but subsequent investigation has led me to abandon this view, although glaciers doubtless played some part in it. A close examination of this region shows that the basin itself is indented with numerous channels that seem to correspond with the breaks in the hills. Were these at one time connected, and if so, how was this connection broken off?—are questions which naturally suggest themselves.

Southeast of Louisville there are two streams—with numerous branches—the Beargrass and Fern creeks. The former joins the Ohio River this side of the knobs, the latter penetrates through them, at least in part, for some of the branches seem to become lost in the Wetwoods. In fact they are really the cause of the phenomenon. In preglacial times these channels had, doubtless, free course, but during the ice age they became obstructed and have remained so until set at liberty by the hand of man. It has been shown in a previous letter to the AMERICAN GEOLOGIST, on Preglacial streams near Louisville, that the mouths of the Beargrass were at one time much larger than at present, which would be the case if they drained the region referred to.

It seems to be evident, then, that this basin is the result of preglacial erosion, and that the Wetwoods are due to the obstruction of these ancient river channels during the Glacial period. When the ice-sheet lay over this region these streams were probably subglacial, and their channels no doubt were greatly enlarged and flooded until partially filled in by the retreating glacier. The summits of the highest hills around Louisville show the effects of erosion; even the tops of the knobs, both in Kentucky and Indiana at the hight of 400 feet are worn and eroded into all kinds of fantastic shapes, and when the clay that covers them is removed the rock looks as smooth as if the water had but receded yesterday. The idea that this deposit of clay covering the rock from four

to twenty feet in thickness, is the result of weathering seems to the writer preposterous. It is either fluviatile or glacial in character. Quite a large number of sandstone boulders have been collected by the writer, and their position in the clay seems to indicate that they are glacial in origin. The knobs, on both sides of the Ohio river, though much broken, remain as hills where streams have not been large and powerful enough to wear them down to the deeper valleys, like the so called Collett glacial valley in Indiana, which by the way, is a *pre*glacial valley, and was long in existence before the ice-sheet covered it. Both arms of the knobs stretch out from the river for the distance of about eight or nine miles, and both break off in the same peculiar way, like the back of a dromedary between the head and the hump. The cause of these breaks where the knobs disappear is the Silver creek channel on the Indiana side, and Fern creek and Salt river, on the Kentucky side. I have been unable to trace out these ancient channels in all of their former ramifications, and it is doubtful if their connections can be exactly determined, but a close examination of this region under consideration, will convince any one familiar with such phenomena, that preglacial streams acting with the ice-sheet operated in the formation of this basin known as the Wetwoods.

Near Old Deposit station, in the center of this depression is a conical hill, perfectly round, which looks as if it might be artificial, but the sweep of the old channels around it bespeak its origin. It seems to have been the site of an Indian village as great numbers of broken flints and arrow-heads can be picked up on its southern slope.

Louisville, Ky., June 9th, 1890. JOHN BRYSON.

PALÆONTOLOGICAL NOTES FROM INDIANAPOLIS. (A. A. A. S.) PTERICHTHYS — CASTOROIDES — EURYSOMA *g. n.* Prof. H. S. Williams of Ithaca exhibited a new and unique specimen of which fragments had been previously known. It consisted of several plates of a large fish from the Catskill of New York. The first description of a fragment of this species was published by Prof. E. W. Claypole in 1883, in the proceedings of the American Philosophical Society, under the name of *Pterichthys rugosus*. Its most notable character is the rugose, radial markings on the surface differing in this respect from any known fossil fish. A second plate has since come into possession of the author of the species which was evidently a lateral plate of the same animal. It is deeply concave and has a similar wrinkled surface.

In the original description the following remark occurs:

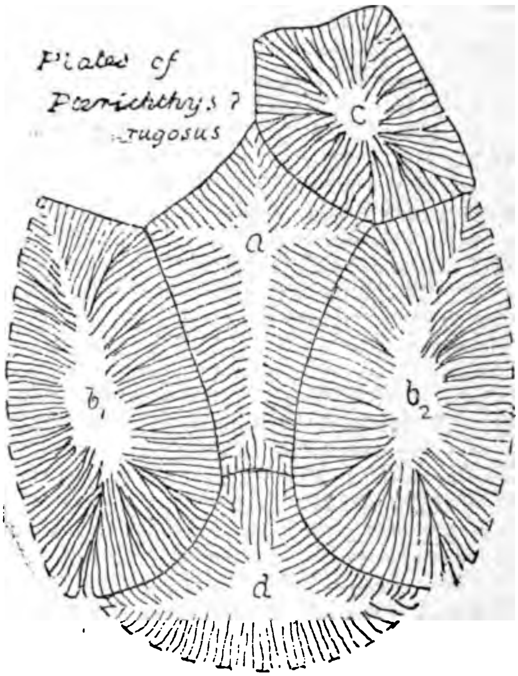
"The outline of the plate corresponds very closely with that of the dorso-median plate of Pterichthys, and were it not perfectly flat I should be inclined to refer it to that part of the exo-skeleton. But this flatness renders it probable that it is the ventro-median or well known "lozenge-plate" of Hugh Miller, the central piece of the armour of the fish on the lower side—overlapped on all sides by the others."

But the additional evidence now attained renders it more probable that the first impression was the correct one, and that the plate in question

is really the dorso-median, in spite of its perfect flatness. Prof. Williams' specimen exhibits it with three other plates evidently in correct relationship to one another.

It is not well to be too confident regarding the details of a creature of which we as yet know so little, but it seems in the highest degree probable that the two larger plates are the post-dorso-laterals and the fourth the post-dorso-median. On that view it is also almost certain that the additional plate above mentioned which has not yet been figured but which came to hand about four years ago, is the dorso-latera- of the left side.

On this view the following outline will represent the position and relation of all the yet known plates of this fish.



Dorso-median (first described),	a
Dorso-lateral, left. (not yet described)	c
Post-dorso-lateral, right,	b_1
" " " left,	b_2
Post-dorso-median.	d

The plates shown in Prof. Williams' specimen are a, b^1, b^2, and d.

Assuming that this fish was not distantly allied to *Pterichthys*, as seems probable from the resemblance in form between their dorso-median plates, the flatness of this specimen, as already said, is very remarkable. In the typical *Pterichthys milleri* the plate in question "rises toward the middle in a roof-like ridge." No ridge or even line

appears on the corresponding plate in either of the two fossils thus far found.

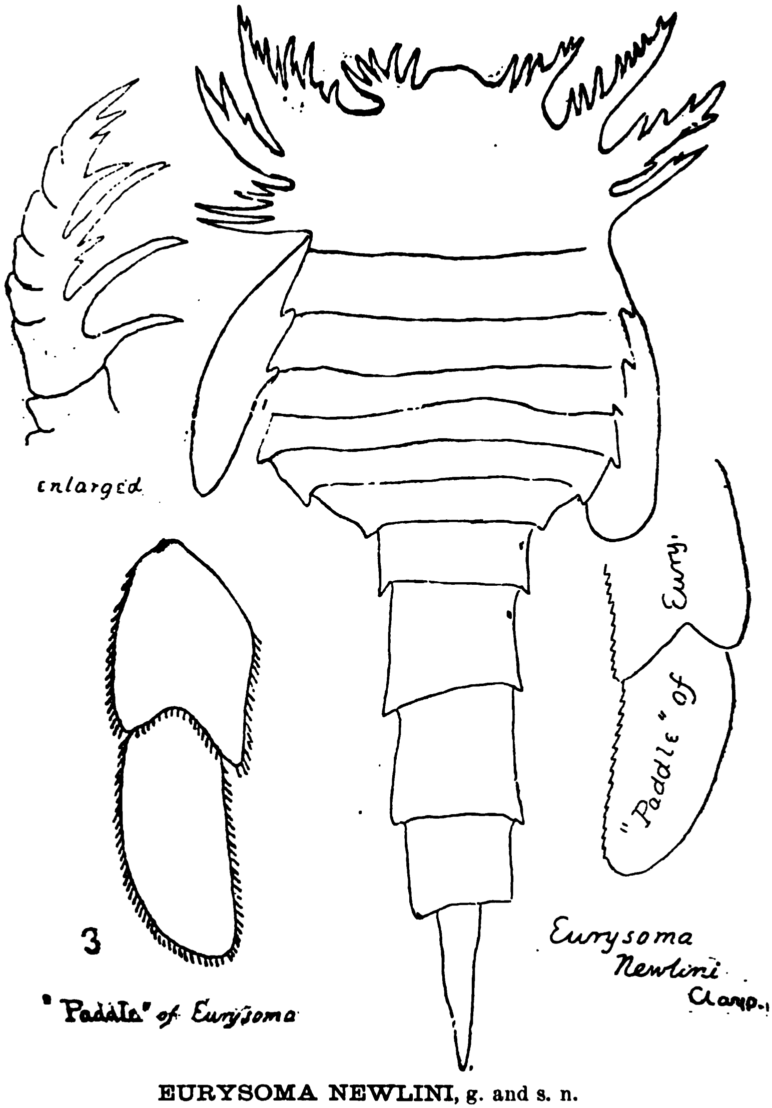
Dr. Newberry, who has seen a print of the specimen, is of opinion that the characters justify a separation from *Pterichthys* and *Bothriolepis* (genera scarcely at present clearly distinct), and has proposed the name *Holonema* in allusion to the wrinkled surface. There are certainly great differences between this fish and the other two genera—differences perhaps sufficient to justify separation—in the larger size of the former, the flatness of the dorso-median plates, and its position with the long and narrow end behind. But as to the sculpture it is doubtful if the difference on this point is great enough to justify another name. Though that of *Pterichthys* is usually considered tubercular, yet a slight examination of specimens, especially those from Scaumenac Bay (*Pt. canadensis*), will show that it is frequently rugose and that the tubercles constantly tend to run together into wrinkles. Hence that species is now often referred to *Bothriolepis*. From the latter the great size of the fossil in question is the main point of distinction. For the present, however, the matter must remain undetermined, and the fossil be called *Pterichthys* (Both.) *rugosus* or *Holonema rugosum*. It is right to add that the exact horizon of the fossils is a little uncertain. They came, however, from either the highest beds of the Chamung or the lowest of the Catskill.

Since the above note was written Dr. Newberry's admirable work on Carboniferous Fossil Fishes has been distributed. Among the species there described is the fossil in question, several plates of which are figured in whole or in part. The central plate (a in diagram) is referred by Dr. Newberry with hesitation, as it was in the original description, to the ventral surface and considered the equivalent of the "Lozenge-plate." It is with diffidence that the writer ventures to differ from so eminent and experienced an authority, but the evidence now accumulated, and especially the fossil exhibited at Indianapolis, seem to leave little or no ground for hesitation. The form of the central plate, the presence of another median plate at its narrow end, the form, size and fit of the lateral plate at its wide end, the direction of the wrinkles, and the number of plates necessary to complete the shield (assuming its near relationship to *Pterichthys* and *Bothriolepsis*, which seems reasonable), all combine to indicate the dorsal rather than the ventral aspect of the fish. The only rebutting evidence is the flatness of the central plate and perhaps its position with the wide end in front, though the last may have little or no significance. There seems to the writer insufficient reason for overlooking the manifest analogy with the dorsal shield of *Pterichthys*.

It is only fair to add that Dr. Newberry's opinion above quoted is merely provisional and therefore subject to revision. It was moreover published before the discovery of the specimen shown at Indianapolis, and consequently the evidence much less complete than what we now possess.

Prof. Joseph Moore, of Earlham College, of Richmond, Ind., exhib-

ited part of the most nearly complete skeleton of the great fossil beaver (*Castoroides ohioensis*) that has yet been discovered. Probably had the find been known in time or had the workmen who were digging the ditch known the value of the bones the entire skeleton might have been



EURYSOMA NEWLINI, g. and s. n.

obtained. Several skulls and numerous other bones and teeth have been discovered but of this giant among the beavers our museums as

yet possess no perfect specimen though it ranged over a wide area in North America. In size it must have been about that of a black bear.

Mr. C. E. Newlin, of Kokomo, Ind., exhibited some tracings from slabs of water lime found in the quarries near that city, which show the outlines of several Crustaceans belonging to the genera Eurypterus Ceratiocaris. These impressions, for they are scarcely more, have been known for eight or ten years past to the workmen as "petrified crayfish" and occur scantily in only one particular ledge of the stone. Some of them so far as could be determined by a hasty examination belong to the species *Eurypterus lacustris*. Others apparently differed and may prove to belong to species yet undescribed.

But a few of these fossils differ so far from all known eurypterids that they must be regarded as representing another and new genus of Crustaceans. The form of the body and the appendages is remarkable and very clearly shown. A full description of this fossil is appended.

Genus (Eurysoma).

Body ovate, narrower in front, abruptly tapering behind into a cylindrical abdomen ending in a spiniform tail.

Head-shield entire, roundly triangular, bluntly pointed in front. Number of segments in thoracic portion uncertain, six visible in the specimens described, ending on each side in a backwardly directed point. Abdominal segments four, subquadrate; beyond these is a sharply triangular spine.

Appendages consist of five pairs of organs the first four of which taper rapidly to a point and are furnished on one or both sides with spines or spinous processes. The fifth pair or the so-called swimming feet, are much thicker and longer than the others and show no trace of che-

late endings. They are apparently two-jointed, consisting of three portions or segments, but in the condition of preservation show no details of structure. As in Eurypterus a fringe of stiff hairs or bristles surrounds their eyes and perhaps covers the whole surface of these swimming feet.

EURYSOMA NEWLINI, s. n.

Animal measuring over all about 10 to 12 inches or even more in length by 4 to 5 inches in greatest breadth. The length may be allotted on the average thus: Head-shield, 2 in., body, 3 in., abdomen, 4 in., tail-spine, 2 in.; greatest breadth of body somewhat behind the middle.

Of the appendages the foremost pair is the smallest with about 5 spines on each; the second and largest pair have at least 12; the third about 8, and the fourth about 4 spines. From the second the appendages diminish gradually in size to the fourth.

The large fifth pair reach only to the hind segment of the body—about 3 inches—and show merely the details mentioned in the general description.

Remarks.—The peculiar form of this Crustacean differentiates it readily from the following genera already known from North America.

Eurypterus.	*Amphipeltis.*	*Pterygotus.*
Eurypterella.	*Stylonurus.*	*Dolichopterus.*

Wider still is the difference between it and the family of *hemiaspids*, which is strongly limuloid in appearance, whereas *Eurysoma* in this respect suggests that genus but slightly. *Bunodella* is the only described fossil of this family from N. America.

It is needless to allude to the genus *Slimonia*, apparently intermediate between *Eurypterus* and *Pterygotus*, but of which so far as I am aware no specimen is yet known from N. America, or to *Echinognathus*, of which only a few fragments are yet known. The differences are manifest.

The swimming feet of *Eurysoma* bear a very strong resemblance, however on an enlarged scale, to those of *Eurypterus pygmæus* of Salter, found in the British Upper Silurian and Lower Devonian rocks, in containing only three segments (two joints) and in the unspecialized rounded form of the outer ends.

The condition of the fossils precludes very minute details. They are for the most part merely black impressions on the surface of the gray limestone. In some cases a thin scale can be seen, but it exhibits no structure. Hence the well known surface marks of the eurypterids cannot be expected. The same remark applies to the eyes and the joints of the smaller appendages. The general outline is, however, remarkably sharp and distinct. The figure herewith given is merely a reduced copy of a tracing from the rock itself.

This description has been drawn up from several tracings supported by examination of three specimens (all yet known) in the possession of Mr. C. E. Newlin, of Kokomo, Ind., after whom the species is named. They were found about three years ago in the Water-lime quarries near that city with specimens of Eurypterus and Ceratiocaris.

Akron, O., Sept. 1, 1890. E. W. CLAYPOLE.

PERSONAL AND SCIENTIFIC NEWS.

PROF. C. H. GORDON, OF KEOKUK, IOWA, has taken a position at the Northwestern University, Evanston, Ill. His future work will be in natural history and algebra.

THE FOURTH ANNUAL SESSION OF THE IOWA ACADEMY OF SCIENCES was held at Des Moines, Sept. 4th and 5th. Mr. C. R. Keyes had the following papers: Evolution of Strophostylus, Age of the Iowa City sandstones and Notes on the Red Rock sandstone; Prof. R. Ellsworth Call read the following papers: Two Quaternary sections near Des Moines, On a Quaternary section eight miles southeast of Des Moines (in connection with Mr. Keyes). Prof. J. E. Todd had the following: Further notes on the geology of northwestern Iowa, Exhibition of volcanic ashes from Omaha, Nebraska, and Shore-lines of ancient glacial lakes. Prof. E. H. Barbour had a paper on Varieties and structure of oölyte.

THE SUMMER MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA was held at Indianapolis, beginning Sept. 19. The following papers were presented: Recognition of mineral contours in thin sections (abstract), A. C. Lane, Houghton, Mich.; Geology of southern Indian Territory, R. T. Hill, Austin, Texas; The Vita crevasse, L. C. Johnson, Meridian, Miss.; The Cuyahoga shale and the Waverly problem, C. L. Herrick, Cincinnati, O.; The geotechnic and physiographic geology of western Arkansas, A. Winslow, Jefferson City, Mo.; The Appomatox formation in the Mississippi embayment, W. J. McGee, Washington, D. C.; The Redonda phosphate, C. H. Hitchcock, Hanover, N. H.; The continent and the deep seas E. W. Claypole, Akron, O.; The Taconic iron ores of Minnesota and western New England, N. H. Winchell and H. V. Winchell, Minneapolis, Minn.

THE COLORADO DESERT. Mr. C. R. Orcutt, San Diego, has lately made an exploration of the arid region that forms the eastern portion of San Diego county, Cal. He reports the existence of large quantities of silicified wood, and the discovery of a coal-field, which he thinks is extensive and should have the attention of capitalists.

AT THE LAST MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (Indianapolis), Section E was presided over by Prof. J. C. Branner, who delivered an address on the *Relations of the United States and State geological surveys to each other, and to the geologists of the country.* The secretary was Prof. S. Calvin, of Iowa City. Following is a list of the papers read before the Section:

Preservation of glaciated rocks—15 min.—By Homer T. Fuller.
An old channel of the Niagara river—15 min.—By J. T. Scovell.
Niagara. A few last words in reply to Mr. G. K. Gilbert's History of the Niagara river.—15 min.—By George W. Holley.
A local deposit of glacial gravel found in Park county, Ind.—10 min.—By John T. Campbell.
Concerning some portions of Castoroides ohioensis, Foster, not heretofore known.—20 min.—By Joseph Moore.
The "Barking Sands" of the Hawaiian islands.—10 min.—by H. Carrington Bolton.
Occurrence of sonorous sand on the Pacific Coast of the United States.—6 min.—By Carrington Bolton.
Floridite, a new variety of Phosphorite found in Florida.—10 min.—By E. T. Cox.
The Columbia formation in the Mississippi embayment.—20 min.—By W. J. McGee.
What constitutes the Taconic mountains?—15 min.—N. H. Winchell.
The formations and artesian wells of Memphis, Tenn.—15 min.—James M. Safford.
Progress in morainic mapping.—15 min.—T. C. Chamberlin.
Remarks on construction of topographic maps for geologic reports.—10 min.—Arthur Winslow.
Notes on the occurrence of Pegmatite in central Missouri.—5 min.—Arthur Winslow.
The amount of natural gas used in glass manufacture.—10 min.—Edward Orton.
Differentiation of subterranean water supplies.—10 min.—J. E. Siebel.
Some of the qualifying conditions of successful artesian well boring in the northwestern states.—10 min.—C. W. Hall.
A notable dike in the Minnesota river valley.—5 min.—C. W. Hall.
Topographic features of the Arkansas marbles.—10 min.—T. C. Hopkins.
The origin of the manganese ores of northern Arkansas and its effect on the associated strata.—10 min.—R. A. F. Penrose, Jr.
The novaculites of Arkansas.—15 min.—L. S. Griswold.
Subsidence and deposition as cause and effect.—20 min.—E. W. Claypole.
On the paleontological and geological relation of closely similar fossil forms.—15 min.—C. A. White.
The crystalline rocks of central Texas.—10 min.—Theo. B. Comstock.
The geology of the Wichita mountains, Indian Territory.—10 min.—Theo. B. Comstock.
The Silurian system and its geanticline in central Texas and Indian Territory.—10 min.—Theo. B. Comstock.
Topographical evidence of a great and sudden diminution of the water supply in the ancient Wabash.—20 min.—John T. Campbell.
Glacial action considered as a continuous phenomenon, having shifted from one locality to another.—8 min.—P. H. Van der Weyde.
Geology of Indian Territory south of Canadian river.—20 min.—R. T. Hill and James S. Stone.
The recent explosion of natural gas in Shelby county, Ind.—20 min.—H. E. Pickett and E. W. Claypole.
Note on the stony meteorite that recently fell in Washington county, Kan.—3 min.—E. H. S. Bailey.
The Bendigo (Brazil) meteorite.—12 min.—By Orville A. Derby.
A new method of searching for rare elements in rocks.—6 min.—By Orville A. Derby.
Observations on the genesis of certain magnetites.—10 min.—By Orville A. Derby.
Mepheline-bearing rocks in Brazil.—10 min.—By Orville A. Derby

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THE TACONIC IRON ORES OF MINNESOTA AND OF WESTERN NEW ENGLAND.*

By N. H. WINCHELL and H. V. WINCHELL, Minneapolis.

In the course of an investigation and report on the iron ores of Minnesota we have learned that there are five principal kinds of ore, and that while they differ mineralogically one from the other, and are associated with different mineral species, they also belong to different geological horizons. These five ores are as follows:

1. The hematites and limonites of the "Mesabi range," the equivalent of the manganesic hematites of the Penokee-Gogebic range in Wisconsin.
2. The gabbro titanic magnetites, whose stratigraphic place is near the bottom of the rocks of the Mesabi range.
3. Olivinitic magnetites and sometimes sulphur-bearing quartzose magnetites, whose place is just below the gabbro eruptive rock, and in the basal portion of the Mesabi rocks.
4. The hematites and magnetites of the "Vermilion range," extensively worked at Tower, belonging in the Keewatin formation.
5. The magnetites of the crystalline schists belonging in the Vermilion formation.

In our discussion of these ores we have attempted to indicate their probable equivalents, as to quality and stratigraphic horizon, in Canada and the eastern portion of the United States. We have little or no difficulty in designating those ores which, in strati-

* Read before the Geological Society of America, Indianapolis, August 22, 1890.

graphic position as well as in metallurgical quality, are the probable parallels of the northwestern ores. These discussions and comparisons will appear in a forthcoming bulletin (No. 6) of the Minnesota geological survey.

In the consideration, however, of the ores of the Mesabi range, we have been led into a somewhat extended re-examination of the literature of the ores of eastern New York and western New England, and we desire to call the attention of geologists to some of the results.

We have for some time considered the Mesabi hematites and limonites, which are the unquestioned equivalents of the manganesic hematites (with small amounts of limonite) of the Penokee-Gogebic range on the south side of lake Superior, as belonging in the primordial zone of the stratigraphic scale. It is not likely that any one will question this conclusion, as it has lately been confirmed by the discovery of primordial fossils in the Animike rocks of this region at points a few miles north of the international line. The fossils have been examined and pronounced upon by Prof. G. F. Matthew.* It is in connection with the ores that occur in these rocks (making the Mesabi iron range of Minnesota), which we designate Taconic, that we desire to offer some remarks touching their probable eastern equivalents.

We were at once struck with their general appearance of parallelism with the Taconic ores of western New England. This general appearance is found to characterize them as ores, and as parts of their associated geological terranes. For instance, if we consider their quality, they are both characterized as limonitic hematites, easily mined, and often manganesic, and they have each been traced back to a carbonate as their original condition. The early speculation of Dewey that they are of derived origin, was seconded by the elder Hitchcock with a designation of the nature of that original condition, and has been followed by Dana, and lately by Irving and Van Hise and J. P. Kimball, in almost a complete demonstration that the ore of this geological horizon, or of these two horizons, was at first in the form of some carbonate, which was largely carbonate of iron. The removal of the carbonic acid, resulting in the oxidation and concentration of the iron by surface waters, has caused locally large deposits of rich iron ore.

*Am. Jour. Sci. (3), xxxix, 145.

If we consider further this general appearance of parallelism, in respect to their associated rock-strata, we find also a striking similarity. We know that the western ores of this horizon are uniformly found in close association with a dolomitic limestone, which is often quite siliceous, or "cherty." It often embraces lumps and apparently angular pieces of flint and jasper of bright colors. It has been described at some length by Irving and Van Hise in their late discussions of the iron ores of Wisconsin.* They estimate that this limestone is sometimes 300 feet thick, and that in other places it apparently is wanting. It has been described as *marble* where it appears at Menominee, but generally it is not in sufficiently large and even masses or beds to warrant that designation. It also appears at the same stratigraphic horizon in Canada, according to the descriptions of the Thunder Bay region by the Canadian geologists. In Canada, however, and in northeastern Minnesota, it has not attracted so general attention, either because it is not so largely developed, or because it has not yet been discovered in outcrop on so large a scale. Underneath this limestone, in Minnesota, is a conspicuous and persistent quartzyte which sometimes is vitreous. This is cut and interbedded with gabbro, and in large tracts is immediately overlain by the great gabbro sheet of that part of the state. This quartzyte has an observed thickness, in Minnesota, of not over 300 feet, but it may be over 500 feet thick. In Wisconsin it is estimated at 300 feet. Overlying the limestone, at least at a higher stratigraphic horizon (though the limestone may be wanting where this observation was made) are other quartzose strata, differing considerably from the lower quartzyte in being finer grained and often with limonitic streaks. Overlying all these strata are black slates with interbedded traps, passing upward into the quartzytes and traps of the Cupriferous (Keweenawan) formation of lake Superior.

If we compare this succession of strata with that of the Taconic region of western New England we are at once impressed with the close resemblance. Overlying the Archean of the Green mountains is the great "granular quartz," which has lately been shown by fossils to belong in the Primordial zone,** and which Dr. Emmons put at the base of his Taconic system. Above this is the great marble belt which Prof. Dana has traced from central Ver-

*Am. Jour. Sci. (3), xxxvii, 32.

**C. D. Walcott, Bulletin No. 30, U. S. Geol. Survey.

mont to New York city, and which at Cortland is overwhelmed, along with the underlying quartzyte, by the gabbros of the Cortland series. This limestone Dr. Emmons styled Stockbridge limestone, and in his scheme he considered it as immediately superjacent to the granular quartz. It is in this limestone, or in immediate proximity to it, that occur all the iron beds of western New England, and of Dutchess, Columbia and Rensselaer counties in New York. Prof. Dana has called attention to this association. Dr. Hitchcock had done the same earlier. That this limestone, which furnishes large quantities of marble, which holds the limonites of the region, which immediately overlies a great quartzyte which is primordial, which has a dolomitic composition, and which is overwhelmed with a gabbro outburst, should have an exact parallel in all these respects in the northwest is certainly a remarkable coincidence of geological data that demands close attention. These are the general considerations that impressed us with the probable parallelism of the Taconic ores of Minnesota with those of western New England.

But we meet here the obstacle, that Prof. Dana has investigated the Stockbridge limestone, has traced it into immediate connection with fossiliferous limestone, and that the fossils there found were those characteristic of the Trenton limestone. He has pronounced the Stockbridge limestone identical with the Trenton-Chazy-Calciferous. In more recent times Mr. C. D. Walcott has come to the same conclusion. We need not refer specifically to their papers. They extend in the volumes of the American Journal of Science from 1872 to 1889. The mainspring which actuates them all is, apparently, the overthrow of the Taconic system.

We were forced, therefore, either to seek for some other explanation of this coincidence, or to abandon the effort to find an eastern representative of the western Taconic ores, or to correct the interpretation which had been put on the stratigraphy of one or the other.

To attempt to explain this coincidence, on the supposition that the limestones and quartzytes concerned are on separate horizons, without an investigation of the evidence, was to traverse the manifest dictates of human intelligence. To abandon the effort to suggest a probable eastern representative of the Taconic ores of the northwest, in the presence of strongly suggested equivalents,

notwithstanding the necessity of a laborious reconsidering of the whole question, both in the west and in the east, was to make a hiatus in our investigation, and was to quail at the appearance of added work. We therefore decided to undertake to examine the problem again. It was divided into two parts and pertained to:—

1. Can there be any mistake in the stratigraphy of the Northwest, such as would, if corrected, allow of this quartzyte and this limestone (and particularly this limestone) being put into the strata of the second fauna?

2. Can there be any mistake in the stratigraphy of western New England which, if corrected, would allow of the Stockbridge limestone being put into the primordial zone?

It did not require a moment to answer the former question. There is no geologist who has examined the rocks of lake Superior who would not at once scout the idea of the Trenton age of any limestone in northeastern Minnesota. No one has ever suggested such a possibility.

We were therefore forced to seek for possible mistakes in the stratigraphy of western New England, as recently interpreted by Messrs. Dana and Walcott.

At the outset we find great confusion in the stratigraphy of western New England. If there be any part of the world where the strata have been variously interpreted, it is the Taconic region. Dr. Emmons' scheme was opposed by an influential school during his lifetime, but was virtually accepted when Barrande and Billings espoused his views on paleontological grounds. There were so many apparent irregularities and exceptions, not to say errors, in the stratigraphy of Emmons, that Prof. Dana reviewed the whole field on lithological and general stratigraphical lines and reached the conclusion that Emmons was wholly wrong, and that the Taconic system had no actuality as a sub-Silurian (Primordial) terrane, but that all the rocks included in it were of the age of the Champlain system of New York. Again, and lastly, Mr. Walcott has gone over the ground, in some parts of the field, and has found fossils enough to establish a great primordial (sub-Silurian) series, correcting Dana in respect to the quartzyte and the "great central slate belt," but approving Dana in respect to the Stockbridge limestone.

Now, it is this final conclusion, respecting this limestone, to which we wish to direct your attention. Does it belong chronolog-

ically immediately above the quartzyte, and thus near the base of the primordial, or does it belong in the zone of the second fauna, the equivalent of the Trenton, or the "Trenton-Chazy-Calciferous?"

It is but just to Mr. Walcott to state that he did not give much attention to the stratigraphy of the eastern portion of the limestone belt in Vermont and Massachusetts, but accepted, and expressed on his map accompanying his last papers in the American Journal of Science,* the conclusions of Prof. Dana, who, again, accepted and perpetuated the conclusion of Rev. Mr. Wing, to the effect that the Stockbridge and Sparry limestones are the same stratum, in general, and that the differences of lithology, as well as the noticeable lack of fossils in the Stockbridge, or eastern belt, are due to greater metamorphism toward the east.

In considering the possible distinctness of these two limestones, there are some things that must be accepted as facts that cannot be questioned. In general, all those facts of observation that have been stated by good geologists have to be admitted. It is only when inferences have been drawn from the facts which the facts do not prove, that we are at liberty to suggest other inferences.

To begin with, then, we must admit there are sufficient facts already published by Messrs. Wing and Walcott to prove the existence of the Trenton limestone in the region, and we may admit that it seems very likely that the Sparry limestone of Dr. Emmons is of the age of the Trenton. The question to be considered next is this: Is there any sufficient proof that the Stockbridge limestone passes into and becomes this Trenton limestone?

We remark at once the absence of fossils from the Stockbridge limestone, throughout its extent in Massachusetts, where it is known to be of the same horizon. We also notice that in all the Taconic region, extending from the northern part of Addison county, Vermont, through Massachusetts into Connecticut (and farther south) there is almost a total lack of recorded fossil localities in the area of what may be considered the Stockbridge limestone. The fossils that have been found are mainly along the western border of the Taconic range, or are in the "magnesian slate" which constitutes the Taconic range.

We also notice that the line of limonite ore mines, as marked

*Op. Cit. Vol. xxxv.

on the geological map of Vermont by Dr. Edward Hitchcock and considered by him a belt of Tertiary age, runs along the eastern edge of the limestone area and not far from the western edge of the quartzyte area, thus coinciding with the possible strike of a limestone of the age of that which accompanies the Taconic ores in Minnesota and Wisconsin.

We note next the existence, in northern Vermont, of another limestone which also has furnished a large amount of marble—known as Winooski marble. According to Mr. Walcott this limestone lies below the Olenellus fauna, and has not yet furnished any characteristic fossils.* He also says it is over seven hundred feet thick (reaching 1,000 feet) and is overlain conformably by 8,000 or 9,000 feet of slate and schists; and in other places he estimates these schists at 14,000 feet, and refers them to the great Georgia formation. The query naturally arises—may not the Stockbridge marble be on the horizon of the Winooski marble? And may not the schists and slates that make up the Taconic mountains—its conformable companions—of the Georgia formation? In the Winooski region, at any rate, there is a marble formation directly overlain by nine thousand feet of primordial slates and schists belonging to the Olenellus fauna. We notice that in continuing southward, while these schists expand into a great area, and really come to make the Taconic range of mountains, the underlying limestone, according to Wing, Dana and Walcott, disappears entirely; and although there is a great non-fossiliferous marble belt, the limestone which constitutes it is, on the same authority, of Lower Silurian age and overlies the same schists and slates—at least is of more recent date, although overlain by a second series of schists and slates. There is, therefore, no unreasonableness in suggesting that the Winooski marble may continue southward and deploy out on the flanks of the Green mountains, carrying with it its conformable companion, the Georgia slates and schists. We may go further and affirm that, in the absence of proof to the contrary, the Winooski marble would be likely to extend southward. Its extension southward would be in a direction parallel with the folds of synclinal and anticlinal axes. If the supposed extension were across such pre-primordial axes there would be reason to expect some of them might cut it off. We have, therefore, in addition to the certainty

*Am. Jour. Sci. (3), xxxvii, 384; xxix, 330.

of the presence of the Trenton limestone in southern Vermont, the probability also of the presence of the Winooski marble.

We next proceed to consider the question in the light of positive facts bearing on the probable existence of the Winooski limestone in central and southern Vermont and in Massachusetts.

We find the earliest evidence comes from the researches of Mr. Wing, as presented by Prof. Dana.

We take up first those facts that tend to prove the existence of only one limestone, and afterward those that tend to show the presence of two.

1. *Facts that indicate the presence of but one limestone.* All these facts have been interpreted by Mr. Dana, and accepted by Mr. Walcott, as proving satisfactorily that there is but one limestone.

(a) *Fossils at West Rutland.* Great stress has been laid on this discovery by Mr. Wing. But if the description be examined, in connection with its accompanying map,* it will be seen that the evidence is far from conclusive. The fossils are all in a comparatively narrow limestone belt, which is isolated entirely from the principal marble belt. The beds all dip east toward the quartzyte, and the appearance indicates that they pass below it. They cannot, however, pass below it since the quartzyte is in the bottom of the primordial, according to Walcott, and the fossils discovered by Mr. Wing are of the age of the Trenton. There is, therefore, proof of general irregularity at West Rutland, such that the dip and the relative position cannot be taken as indices to chronologic sequence. Therefore the eastern belt of limestone at West Rutland cannot be assumed to be the same stratum as that containing the fossils. Indeed Mr. Wing particularly emphasizes the fact that after search along the strike northward the West Rutland limestone ceases, and the upper and lower slate belts come together in the same manner as on the south. In this respect he corrects the official geological map of Vermont.

(b) *Fossils at Sudbury.* According to Dana this limestone area is a narrow isolated belt similar to that at West Rutland,** or has a narrow connection with it. The fossils indicate it is also Trenton, but there is no evidence that it is connected with the great eastern marble belt.

*Am. Jour. Sci. (3), xiii. 334.
**Am. Jour. Sci. (3) xiii, 339.

(c) *Fossils at Hubbardton and West Castleton.* These are also far west of the great marble belt and in the midst of the "great central belt of slates," in narrow belts of limestone, one being but sixty yards wide. There is here no connection with the great marble belt.

(d) *Fossils at East Cornwall.* The fossils identified here by Billings show the Trenton limestone. But this is also on the course of the great slate range, and seems to be affected by some irregularity similar to that at West Rutland, since the strata all dip eastward, and are represented to pass below the quartzyte. The fossils in Shoreham, West Cornwall and Orwell, reported by Mr. Wing, while probably showing the Trenton limestone, are too remote from the marble belt to be considered, in this inquiry, as affording any demonstration, one way or the other.

(e) According to Mr. Wing's observations, the limestone containing Trenton fossils along the east side of the slate belt in the Otter creek valley, continuing northward from West Rutland, passes in an unbroken area in the northern part of Sudbury, round the northern end of the slate belt and unites with a similar limestone on the western side, and thence passes southward through western Weybridge and Cornwall, having slates above it which he refers to Hudson River slates. Whether this be correct or not, (and we have no disposition to question it) the eastern belt of marble continues uninterruptedly in a belt further east, and wholly on the east side of Otter creek, and runs further north, into Monkton, forming an independent northward prong, like that of a separate formation, accompanied all the way by the belt of iron ores, as represented on the geological map of the Vermont survey.* The synclinal therefore, that is described here by Wing and by Dana, may consist of the Trenton, overlain by the Hudson River slates, but that will require a correction of the late map of Mr. Walcott, for he has colored these slates as of the Georgia (Olenellus) formation.** At any rate, so long as Mr. Walcott differs from Mr. Wing in the interpretation of this supposed synclinal, Mr. Wing's reasoning and his observations cannot be taken as demonstrating the identity of the two limestones, which is the only point we wish to make at this place.

*It probably runs below the red sandrock in Monkton, while the other limestone terminates in a flattened synclinal by the rising of the red sandrock underneath it in the same town.

**See his map, Vol. xxxv, 346, Am. Jour. Sci.

(f) *Fossils in New Haven.* So far as these are determined they depend on very imperfect specimens, and as they are in beds that underlie some quartzyte, and which appear to be of the Winooski marble series (Dana) they do not have any affirmative bearing on the existence of the Trenton limestone.

(g) *Fossils discovered by Mr. Walcott.* So far as the new localities of Trenton fossils, lately brought to light by Mr. Walcott, have a bearing on this question, they are those which are nearest the eastern marble belt, viz.: those on Mt. Anthony and those in Pownal.

Those fossils discovered in Pownal are taken to be from the Stockbridge limestone, or from the "eastern belt" of limestone; and as they concur in testimony with those from farther north on the western side of the Taconic range, Mr. Walcott makes the unqualified affirmation (A. A. A. S., 1887, 213) that the Stockbridge limestone is of Trenton age. We cannot accept the inference, because we find reason to believe the Stockbridge limestone is not there represented. Any one examining Mr. Walcott's map will see that there is at that point an abrupt jog to the eastward in all the formations. Coming from the north the belt of the quartzyte is suddenly broken off and does not appear except at several miles further to the south and east. The eastern belt of limestone in the same manner jogs several miles abruptly to the east, while the western belt ceases in the line of its regular trend and is thrown into the line of strike of the eastern belt. Whether there be at the same time a sinking of the Stockbridge limestone so as to allow the Trenton to make the surface rock (as is quite probable, regardless of the eastward jog), is immaterial. It cannot be denied that quite suddenly and singularly all the formations are jogged out of their courses, a remarkable fact to which Prof. Dana has called attention. In general the Taconic range of hills runs through here, and some of these hills seem to be formed of synclinals of the Hudson-Trenton terrane, as represented, but the existence of the Stockbridge limestone in these hills is far from proven.

Those fossils that are reported by Mr. Walcott from Mt. Anthony, and specially those from Graylock, are subject to the same explanation. Those found even on the east side of Mt. Anthony leave room still for the strike of the Stockbridge limestone along east of Mt. Anthony, according to the coloring of Mr. Walcott's map, and Dr. Hitchcock's map represents it as continuous through Bennington and Pownal, accompanied by the iron-ore belt.

(h) *Fossils discovered farther south.* Some of the limestones farther south are proven by fossils to belong to the primordial, and some to the Trenton-Hudson terrane. But only on very general considerations could either of these be claimed to be the representative of the Stockbridge limestone. So far as this evidence goes it demonstrates the existence in Dutchess county of a limestone on about the same geological horizon as the Winooski limestone, and also on the same horizon as the West Rutland limestone, and it leaves us to infer that both of these limestones continue in the line of strike between those points.

2. *Facts that indicate the presence of two limestones.* If we seek for the positive facts that go to show that there is another limestone horizon, much lower than the Trenton, running through western Vermont and southward, we get the first evidence (independently of Hitchcock and Emmons) again from Mr. Wing, and secondly from the stratigraphic descriptions of Prof. Dana.

(a) *Facts from Mr. Wing.* It should be borne in mind that by the discovery of fossils in the quartzyte Mr. Walcott has demonstrated that it belongs in what he called middle Cambrian (Olenellus zone), but which he has later ascertained to be the lowest of the sub-faunas of the "Cambrian."* Therefore, there must intervene between it and the Trenton, not only the Winooski limestone, but the great Georgia formation, an interval that measures in Vermont at least 15,000 feet of sediments.

We find that Mr. Wing describes the quartzyte as *interstratified with the overlying limestone.* This he does not once, nor twice, but commonly, and wherever he speaks of the contact of the two terranes.** This is clearly brought out by his diagrams, and particularly by that giving a section from East Shoreham on the west to Leicester on the east. Whatever may be the errors of stratigraphy farther west, which might be demonstrated respecting this diagram, there can be no question about so simple a point as the interstratification of a limestone with a sandstone, which is represented as occurring near lake Dunmore in Leicester. It was near this place (lake Dunmore) that Mr. Walcott found primordial fossils in this quartzyte. There could be no stronger evidence not only that these two are of one age (and not one primordial and

*Position of the Olenellus fauna in North America, Am. Jour. Sci. xxxvii, 374.

**Am. Jour. Sci. xii, 340. 407, 414.

the other Trenton), but that they both belong in the primordial zone.

(b) *Facts from Prof. Dana.* Some of the localities described by Mr. Wing were visited by Prof. Dana,* who has given his own diagrammatic sections of the relations of the limestone to the quartzyte, and has shown the same interstratification. Some such sections were made in New Haven and in Monkton; and his conclusion is to the effect that the Eolian limestone** includes "even limestones and dolomites of the red sandrock series"—i. e., may contain limestones belonging in the Olenellus zone.

(c) We might mention here the fact that an "Olenellus limestone" has recently been described by Prof. Dwight, in Dutchess county, N. Y., overlying an "Olenellus quartzyte" (Am. Jour. Sci. xxxiv, 30); and that it occupies the area which Prof. Dana had colored on his map as Trenton-Chazy-Calciferous. This only inferentially bears on the question of the extension of a primordial limestone from central Vermont to Dutchess county.

With this we think we have shown the interesting fact that there is a primordial limestone in western Vermont, the probable equivalent of the Stockbridge limestone, and that to it belong the numerous limonitic iron deposits of the Taconic region. There is, therefore, no good reason for rejecting the idea which we first entertained, viz., that the iron deposits of the Taconic rocks in Minnesota (the Mesabi ores, excepting the titanic gabbros) are on the same stratigraphic horizon as the Taconic ores of western New England.

There are some corollaries that spring from this result, to which we might call attention, but we will mention only one: It retains the Stockbridge limestone in the primordial zone as a distinct terrane immediately overlying the quartzyte, or granular quartz, in the exact place assigned it by Dr. Emmons in his Taconic system.

Minneapolis, August, 1890.

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*Am. Jour. Sci., xiii, 407–409, 411.

**This was the name applied by Hitchcock to the whole Vermont marble belt, on the ground that it was essentially one formation.

THE STRUCTURE, CLASSIFICATION, AND ARRANGEMENT OF AMERICAN PALÆOZOIC CRINOIDS INTO FAMILIES.

By S. A. MILLER, Cincinnati.

There have been described from North American palæozoic rocks. 1,100 species of crinoids, which are referred to about 110 genera. The arrangement of these genera into families, based upon uniform and consistent rules, is the object of this article.

When I published my work on North American Geology and Palæontology, I proposed a few new family names, but, as my object then was to present the state of the science as it existed, and not to write an original treatise on any one branch, I generally followed the classification of others, and, as they were not in accord as to family characters, the families, as there given, are not of equal value. The new family names which I proposed were not defined and hence were used only provisionally, and because I could not refer the genera to families that had been limited and defined. Indeed, I did not have the time to properly classify the genera into families, nor access to the fossils for the purpose of verifying such classification if I had taken the time from other duties. Since that work was done, I have had an opportunity to inspect a large lot of crinoids from Mr. Gurley's collection in addition to those in my own cabinet, and to review the various systems of classification in use in this country, and now propose to present my views of family classification.

I would desire to state, in the first place, that, in many instances, I do not agree with the views of Wachsmuth and Springer, as to family characters and the classificatory value of the structural parts of criniods, and while I may refer the same genera to some families that they do, yet the reasons therefor are not the same. I believe families should be established upon the structure of the calyx, and, for this purpose, the number of the basal plates is first in importance; second in importance is the presence or absence of subradials; third the presence or absence of regular interradials, and, after this, comes the structure of the azygous side and other parts. For the purpose of showing how radically we differ, I will quote a few sentences from their work on the Palæocrinoidea.

"A subdivision according to the number of basal plates may facilitate elementary studies, but it is certainly not a natural classification."

"In the first part of this work we have discussed somewhat fully the relations of the underbasals which we took to be the product of growth in geological time, introduced gradually by interpolation between the basals. It is very remarkable that although the introduction of underbasals dates back to the Lower Silurian, as a rule the genera in which those plates are found differ at no time materially from those in which they are wanting."

We have in the introduction to this work, page 17, dwelt at some length upon the basals or first ring of plates below the radials; and believe we have shown that the basal disk, whether composed of one, two, three, four or five pieces can almost invariably be reduced to five elementary pieces, and that all deviations from this number have been produced by anchylosis of two or more of the original segments. This of itself is a strong argument against a classification based upon the number of these plates."

"It is apparent from these facts that neither the existence of underbasals, nor the modifications which took place in the basal disk, had any such corresponding effect, upon the general structure of the crinoids, as to entitle them to be considered characters of family importance, though in distinguishing subordinate groups they may possess some value. The radial and interradial plates are elements of far greater value."

They maintain that "a character in forms of the same geological age may be generic in one case and only specific in another," that "arm structure is of generic importance as a rule, but scarcely of specific value in exceptional cases." To neither of which views do I subscribe. So many of the opinions presented in the first part of the Palæocrinoidea are withdrawn or declared to be erroneous in the third part, and in subsequent papers, that one cannot be certain, when quoting their expressions, that he is really giving their latest views, unless he is a constant student of their productions. For instance, the groove in the arms of crinoids was almost universally covered with small plates whether the arms had pinnules or not, but in the first part of their work they say:

"It is here important to note that in those genera in which the ambulacral groove is thus covered, no regular pinnules have ever

been observed, and moreover the construction is such, that no additional pinnulæ could have existed ; while on the other hand, no covering has ever been discovered in forms with true pinnulæ."

After I described the plates covering the ambulacral grooves, in Glyptocrinus, notwithstanding the long flowing pinnules, I believe they modified their views, but, at present, I have no reference to the revised opinion. Their greatest mistakes seem to me to have arisen, however, from the use of the mongrel word "*underbasals*," and a complete misconception of the purposes subserved, in the animal economy, by the plates referred to, and the consequent neglect to give the basal plates the examination their importance demanded. They frequently discuss "rudimentary underbasals," when no such thing was ever found in a palæozoic crinoid, and from the structure of the calyx, and purposes subserved by the basal plates, "rudimentary underbasals" never could have had an existence in any of them. For instance, they say on page 7, 2d part, "Glyptocrinus was originally described with five basals and no underbasals. Hall afterward discovered in G. decadactylus, small pieces concealed in the basal cavity, so rudimentary, however, that both he and Meek hesitated to call them basals, although both authors apply that term to the proximal plates in all other cases. Meek distinguished them as "subbasals." We have examined the plates in question very carefully in the species named, and find them, although very rudimentary, placed within the basal ring; hence they are according to our terminology, true underbasals, and not as Hall describes them a 'quinquepartite' upper joint of the column;" and again, on page 186, 2d part, "Glyptocrinus differs from Glyptaster in having rudimentary instead of moderately developed underbasals." After I had shown that there were no such plates in Glyptocrinus, they admitted on page 102, 3d part, that the absence of underbasals in this genus "is clearly proved."

They said of Heterocrinus in the first part of Palæocrinoidea : "The absence of underbasals in some of the species is a good illustration of our views that the underbasals do not constitute elements in the structure of the Palæocrinoidea, but are merely the result of growth in geological time." Again they say: "Underbasals, minute, in some species almost undeveloped, and appearing externally as subtrigonal points at the lower end of the sutures between the basals ; in some species apparently wanting

entirely." But in the third part they state correctly that there are no underbasals in Heterocrinus, and having studied the genera belonging to the Heterocrinidæ, they defined them as monocyclic. It will be readily seen that where such crude and erroneous notions exist about the principal plates of a crinoid, and the same plates bear two different names, the family classification must be imperfect, and governed by the whims of the various authors.

P. Herbert Carpenter had an opportunity of studying some living crinoids, after which, in his abuse of Dr. Hambach, of St. Louis, he reasoned, through that conduit of English ignorance and conceit, "The Annals and Magazine of Natural History," as follows :

"I have the strongest conviction that the would-be interpreter of extinct fossil forms starts at a very serious disadvantage, if he does not commence by obtaining the best possible information about the morphology of their nearest living representatives. (As I have done.) In order to understand, even with an approximate degree of correctness, extinct groups, such as the blastoids, merostomata, dinosauria, and others, a far more extensive acquaintance with the recent members of the same subkingdom is necessary than for the interpretation of fossil brachiopoda, sponges, corals, mollusca, and fishes, the morphology of which cannot have differed in any important respect from that of the recent species. Without such a preliminary study, no collector, however zealous, can hope to arrive at any rational conclusion (as I can) about the functions of the different structures which he may discover by the careful examination of his fossils."

I have inserted the words in parenthesis to smooth down the application to Dr. Hambach, who was completely undone by this style of reasoning, for he thought his "extinct fossil forms" were living fossils, until P. Herbert Carpenter told him most emphatically, in parenthesis, that "Mr. Hambach has never seen a living blastoid."

As examples of the effect his study of the "living representatives" has had on his "understanding" of the "extinct fossil forms," we may refer to his morphological statement that Hybocystites combines blastoid rather than cystidean characters, with those of crinoids. That Haplocrinus is a synonym for Hybocrinus, notwithstanding there is only one azygous plate in the

former, while there are two in the latter, and other important structural differences, and he at once proceeded to redefine the latter genus so as to include the former. Speaking of Xenocrinus, he said "I cannot help suspecting that a better knowledge of this type (Xenocrinus) will lead to its absorption into Retiocrinus." He said, "Hybocrinus is a crinoid of very embryonic type. The relatively large size of the basals and the retention of the anal plate, together with the simplicity of its arms, and the absence of pinnules, all indicate its low stage of organization." He regarded Bærocrinus " as a permanent larval form, which has only developed three of its five arms," and Haplocrinus is a "persistent larval form." Wetherby illustrated and described the upper azygous plate of Hybocrinus as "rounded and crenulated at its distal extremity as well as much thickened;" this the doughty Carpenter disposed of by saying he had received a specimen from Mr. Wachsmuth on which he could "make out little or no trace of crenulation."

It would not be necessary to point out his illiteracy, for he even uses capital letters for specific names, or lower case as it may happen, showing his want of a common knowledge of grammar, and recklessness in the symmetry of nomenclature, were it not for the fact that a mutual admiration society sprang up between him and Wachsmuth, and Wachsmuth adopted many of his blunders and republished them, thus giving currency to them throughout the country and injuring the progress of knowledge. It is true that Wachsmuth has refuted some of his vagaries and unwarranted conclusions, but he adheres to many of his innovations in nomenclature, though unwilling to go so far as to call all the regular interradial and vault plates oral plates and all the azygous plates anals.

The basal plates of a crinoid rest directly upon the column and are truncated by the columnar canal, around which the animal was attached by ligaments, the scars of which are very frequently preserved. The subradial plates are never basals nor are they in any sense homologous with the basals. In 1879, P. Herbert Carpenter disregarding the original definition and illustration of Heterocrinus by Hall, and the equally plain illustration and positive statement of Billings, that there were no subradial plates in the genus, or not having the sense to understand an illustration and definition, asserted there are subradials in Heterocrinus

and proposed to call the subradials, which had no existence, the "basal" plates because he said they were the genital plates, and the basals he proposed to call the "*underbasals*" a mongrel word, part English and part Latin. This was a case of pure ignorance, assumption and conceit. Only one overgrown with self-conceit would propose to change the nomenclature in any branch of Natural History, where no change is demanded in the interest of science, and only the most illiterate would propose in science a mongrel word formed from two languages, and only the most ignorant would select for the application of a new term, an object which has no existence in nature whatever. The assertion that the subradial plates in any palæozoic crinoid are genital plates is purely gratuitous, and not warranted by any of the known facts relating to crinoids. It would have been equally as correct if he had asserted that the subradial plates were the seat of the soul, and he might have fortified the assertion by claiming that he had seen the blue ethereal substance floating around them. We were surprised however that he coined the word from English and Latin for he affects profound learning in the German, and like the politician enamoured during a campaign of the "sweet German accent," he frequently quotes snatches from German authors to make his usually poor English more incomprehensible. That he did not propose "*unterbasals*" for the basal plates of a crinoid and thus make himself strong with the Germans may have been an oversight, but if he had known the Indian tongue, he would have done himself proud by calling the basal plates "*hatapostlukbasals*," and he could have strengthened his position by commencing the word with a capital letter, as he does specific names.

Four years later he wrote that "Most of the leading writers on the crinoids" had adopted his nomenclature for the plates of the crinoids, and he mentioned them. There were in all six persons, two of whom were from America, Wachsmuth and Wetherby. It must have done the souls of Wachsmuth and Wetherby good to learn from such high authority that they, "constituted most of the leading writers on crinoids," in this country. We learn from Wachsmuth and Springer's Palæocrinoidea pt. 3, p. 8, that two years later, Prof. Williams had joined this host of "most of the leading writers on crinoids," Wachsmuth and Wetherby. It may be in the additional five years that have elapsed since the name "*underbasals*' was proposed, others have used the word to add

confusion to the definition of crinoids; but it is to be hoped that each one does not constitute "most of the leading writers on crinoids," in this country. And it is high time American palæontologists would cease to look to England for information, where less is known of its own fossil crinoids, than happens to the lot of any other country, in which there is any pretension to palæontological knowledge, and where more shallow pretenders vent their stupid hypotheses as to the fossil tests of these animals than exist in any other land.

Prof. D. S. Jordan in "Science Sketches," very appropriately says: "The chief aim of the law of priority, like that of the law of primogeniture, is not the survival of the fittest, nor yet justice, but *simply fixity*;" and the application of this rule should prevent the most destructive innovator from interfering with the long established names of the plates in the calyx of a crinoid; besides there can be no more appropriate and truthful names than "basals" and "subradials." Subradial plates occupy a subradial position, they are neither radial nor interradial but one half is below one radial series and the other half is below another radial series. Basals are always basals and never "underbasals." In some genera they are below the subradials, but in other genera the subradials extend below the basals, while the basals, in the interior of the calyx, project higher than the subradials.

There are no anal plates below the arms in the calyx of any palæozoic crinoid, and there is no more reason for calling the plates in one interradial area anals, in the present state of learning, than there is for calling them orals. The word "azygous" is applied to them because it is noncommittal, and simply indicates that the plates are not the same as those in the other interradial areas. The opening in the azygous side of the vault or in the proboscis, may be an anal opening, and, if so, the plates surrounding it or covering it might be called anal plates, but the name cannot be applied properly to any other plates of the body. The course of evolution was progressive toward more complicated structures, in crinoids, until the Subcarboniferous age; here they seem to have attained their most perfect existence. The living crinoids are the remnants, probably, of a long line of retrogression, the degenerate descendants of more highly organized ancestors—wherein some of their parts are of comparatively modern origin, and others, which the ancestors possessed in a high degree,

have wholly departed, so that not even a rudimentary plate or scar is left to indicate the functions once exercised. Where progression has been the rule, in the development of any class of animals, we may look to the embryology and the growth of the young for reflected light on the fossil remains of past ages, but where the evolution has been backward, for geological cycles of time, the study of embryology of the degenerate descendants, sheds but little light, if any, on the primitive ancestry. To speak of a fossil crinoid as a "permanent larval form" or as an "embryonic type" is, therefore, unenlightened affectation.

The basals, in all palæozoic crinoids, were the first plates to become fully developed, and, after this, they retained the same position, respecting the column, through all further stages of the growth of the animal, as is shown by the uniform projection of the basal disk beyond the column, in all specimens, large and small, in the same species. It is the practice in describing the form of the basal plates to ignore the side truncated by the columnar canal and treat the plates, in description, as if they came to a point at the center of the columnar canal, which of course is never correct, and to illustrate them by cutting off the lower end so that the plates united will leave a pentagonal opening, with the angles at the suture lines of the plates, which is never correct. In fact, I never saw a correct diagrammatic view of the calyx plates of a crinoid, though the basals united are sometimes correctly illustrated. The size and form of this truncation is dependent upon the shape of the columnar canal, but the angles of the canal never unite with the suture lines of the plate; on the contrary, the rays or angles of the canal truncate the plates, and the suture lines of the plates strike the sides of the canal or extend to the body of the canal between the rays.

Wetherby described the basal plates of Pterotocrinus as excavated for the column and thickened and carinated at the outer edges of the columnar excavation, and I infer, from what he said, that his specimens also preserved the evidences of ligamental attachments around the canal. In the "Description of some new genera and species of Echinodermata from the Coal Measures and Subcarboniferous rocks of Indiana, Missouri and Iowa" by myself and Mr. Gurley, it was shown that the base of Ulocrinus is strengthened by the thickening of the plates around the part to which the column attached, and by the anchylosis of

the basal plates. There is an external circular depression into which the end of the column was inserted, and this depression is surrounded by a rim to afford further strength to the point of union between the column and the body of the crinoid. At least three plates of the column were inserted in this circular depression, one of which had an extended rim beyond the column that filled a circular furrow on the interior of this depression which locked the column in the basal plates. The first plate of the column at the base of this circular depression is thin and radiately ridged to interlock with the second plate. The rays of the opening on the internal side of these plates are flanged so as to enlarge the end of the columnar canal as it passes through the basal plates; this enlarged opening is surrounded by a rim for some kind of muscular attachment and to give strength to this part of the calyx. On the outside of this rim there are radiating ligamental furrows or vascular markings for the attachment of the animal sarcode. These characters are well shown by the illustrations. The basal plates of Eupachycrinus magister are also illustrated, showing the conical elevation in the interior of the calyx pierced at the summit by a five-rayed opening for the columnar canal, with the rounded ends of the rays truncating the plates. The pentagonal opening is surrounded with ligamental scars or radiating ligamental lines while the other parts of the internal sides of the plates are smooth. I have seen the same evidence in the basal plates of Delocrinus. I have the basal plates of a Glyptocrinus showing the thickening of the plates internally around the five-rayed canal and bearing evidence of ligamental atttachment. It is well known that the end of the column, in all palæozoic crinoids, is so firmly attached to the basal plates, that it is rare to find a good specimen where the column has been separated from the basals, leaving the place of the columnar attachment in a good state of preservation. I have before me a Batocrinus, with a hemispherical depression at the base, which is radiately furrowed surrounding the pentagonal opening for the columnar canal, for the firmer attachment of the column; and a Poteriocrinus furrowed in like manner for the attachment of the column, and showing a rim on the basal plates surrounding the point of attachment. I have a specimen of Anomalocrinus showing the anchylosis of the upper joints of the column and of the column with the basals, and after examining specimens in different

genera, I have concluded it is not uncommon for the plates of the column, at the upper end, to be anchylosed together. The only ligamental scars in the calyx of any crinoid thus far discovered surround the columnar canal. It follows therefore that the basal plates are the most important in classification of any of the plates of the calyx, because the animal was attached to them, while the other plates subserved the inferior purpose of simply enclosing the other parts of the animal sarcode.

It must be apparent, therefore, that there can be no rudimentary basals, none that are developed from the upper stem-joint and none except they are large enough to surround the columnar canal and with area enough for the muscular attachment. The anchylosis of the basal plates is as common in genera having no subradials as it is in those having them. It would appear, that the attachment of the column to the basal plates, the passage of the columnar canal through them, and ligamental attachment on the interior, held the basal plates firmly in one position, and while, in their younger state, they were capable of growing and conforming to the alternate arrangement of the plates of the column and the succeeding plates, in their more advanced state, the growth terminated in secreting the material that anchylosed the plates.

The earliest crinoids had five basal plates and such forms continued to exist throughout palæozoic time. Those having four basal plates appeared in the latter part of the Lower Silurian and disappeared in the Devonian age. Those having three basal plates appeared in the Lower Silurian and disappeared with the Subcarboniferous, and those having only two basal plates are confined to the Subcarboniferous and Coal Measures. This statement also tends to prove the significance of the basal plates, in classification; besides the form of the basal disk must, in all cases, control more or less the number of the succeeding plates and the structure of the calyx and body of the crinoid. For these reasons, the number of basals and the shade of the basal disk are of the first importance, and families should be so formed as to include only genera having the same number of basals and substantially the same form of the basal disk.

The second character of family importance will be found in the presence or absence of subradial plates. The only known function performed by the subradials is to increase the capacity of the

visceral cavity surrounding the area of ligamental attachment to the test. In some genera they cover half the calyx below the arms, and in all cases they materially affect the form and structure of the calyx and body of the crinoid. Where the plates are large, they were supported in position by ligaments in beveled sutures, as in Eupachycrinus, or by peculiar denticulated or serrated edges such as occur in Poteriocrinus and in Arthracantha, as illustrated and defined by Hinde, or in Ulocrinus as figured and described by myself and Gurley. For the purposes of classification, therefore, no family should include genera having subradials and those in which they do not exist.

The next family character will be found in the presence or absence of regular interradial plates. These plates allow breadth to the body, and though, in their extension over the vault and in other respects, they may sometimes sink to generic or specific importance, yet the fact of their presence or absence is always of family value. The position of the first interradial is of high classificatory value, and genera supporting the first interradials on the basal plates are never to be associated in the same family with those supporting the first plate between the upper sloping sides of the first radials.

The next in family importance are the azygous plates. The structure in this part of the body is frequently complicated and is always of generic importance and frequently of family value. For instance, a genus having an azygous plate resting on the basals is not generally, to be classed in the same family with one having the azygous plate truncating a subradial, for the whole structure of the azygous sides of the genera is different in these cases, commencing with the position of the first plate.

I regard each plate, in the calyx of a crinoid, to which I have attached family importance, as an independent morphological element, and, except in the specimen figured from my collection in Ohio Palæontology, by Meck, under the name of Anomalocrinus incurrus, where there occurs an extra basal plate below the termination of a suture dividing a radial, I have always found the plates the same in each genus.

The structure of the arms, I think, is never of family importance, and above the brachials never of generic importance, though always of specific value. An illustration or two will suffice for the demonstration of this opinion. In Dichocrinus

we have a species with small subquadrangular pieces forming simple arms, another with arms composed of rather large cuneiform plates, and another with arms composed of the double series of interlocking plates. In Poteriocrinus, the species have arms varying in number from ten to fifty, and the structure of the arms varies almost as much as their number does.

The shape of the column is probably of generic value. The vault and proboscis have characters of family value but they are too little understood to base any general classification upon them. But, where they have been investigated, they afford additional evidence in support of the families established on the structure of the calyx as herein above indicated.

[TO BE CONTINUED.]

PILOT KNOB: A MARINE CRETACEOUS VOLCANO.

By Robt. T. Hill, Austin, Texas.

WITH NOTES ON ITS PETROGRAPHY.

By J. F. Kemp, Ithaca, N. Y.

The accompanying maps and figures, with my previous article on this region[1] illustrate an interesting occurrence of ancient volcanic phenomena in the vicinity of Austin, Texas.

This city is situated upon the Colorado river, at the junction of the Grand and the Black Prairie regions of the state. The stream here emerges from the deep, rocky cañon of the Grand Prairie and broadens into a fertile valley of Quaternary sedimentary terraces as it enters the Black Prairie. The river cuts across the general strike of all the formations of the region and thus affords an admirable insight into its stratigraphic history, giving within fifty miles a display of rock sheets from pre-Cambrian to Quaternary.

Among the varied topographic features about Austin are some low rounded hills which, appearing above the horizon of the Black Prairie seven miles southwest of the city, present a peculiar aspect. Upon closer study these hills are found to consist of several cusps of igneous rock rising from a circular depressed area of about 1,000 acres, and projecting through and above the chalky strata of the Black Prairie which surround it on every side, as

[1] See "A Portion of the Geologic Story of the Colorado River of Texas." American Geologist, May, 1889.

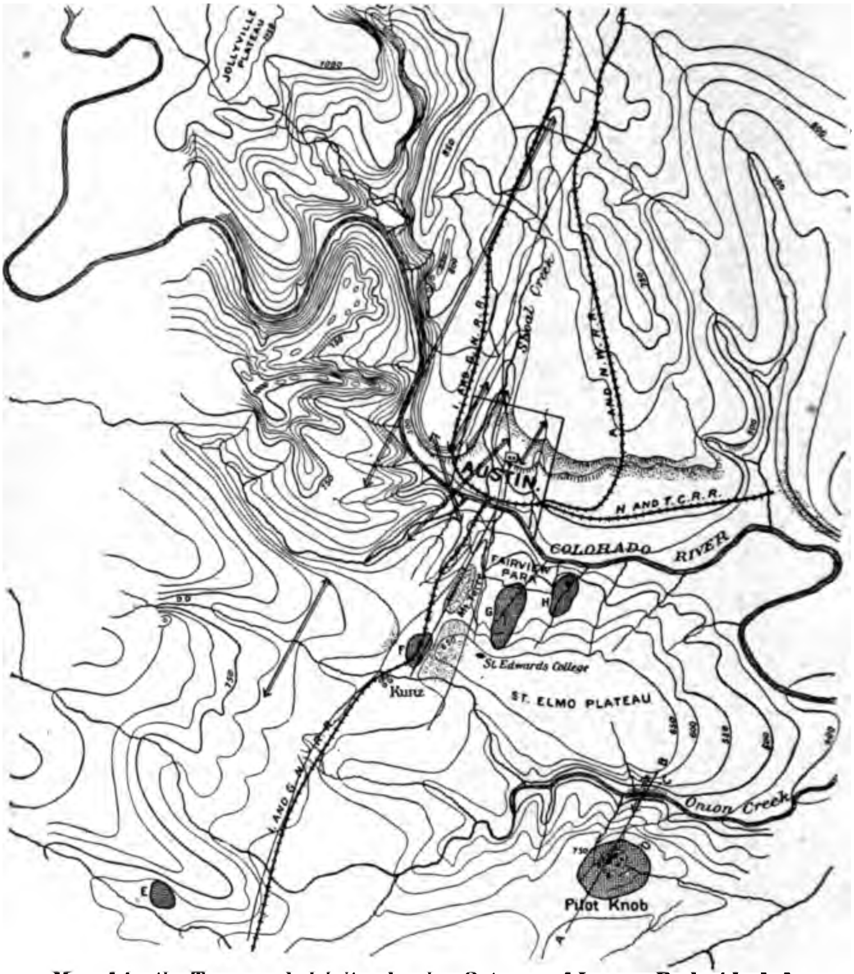
seen in the cross section (Fig. 2, and the map). The hills have an altitude of 750 feet above sea level and 50 above above the surrounding prairie.

They are composed of a hard black rock, the exact lithologic constitution of which, as shown by Prof. Kemp in the accompanying article, is that of limburgite or nepheline basalt. The basalt has an imperfect columnar structure nearly vertical at the south extremity of the hill, (Fig. 2, 1 and 2 of the section) and nearly horizontal at the north side. The flat region between the basaltic hills and the chalky perimeter of the igneous area is filled with a soft yellow amygdaloidal exfoliating material some of which is undoubtedly the product of basaltic decomposition, while in other places it resembles volcanic ash. The exfoliations are perfect and resemble the illustration of that structure given by Geikie.

Proceeding in any direction from the basaltic hills which form the center of the whole outcrop the average distance to its edge is about one half mile, where excellent contacts with the chalk are found. The chalky stratum forming the margin of this area throughout its whole extent is crenulated into gently waving undulations and presents different aspects of hardness. In places of direct contact with basaltic material the chalk is converted into hard marble; where the ash-like material intervenes between the basalt and chalk the latter retains its soft unaltered pulverulent nature (Fig. 2).

The induration of the chalky sheet away from the central hills and its metamorphism are clearly indicative of activity after the deposition of the chalk and would be a sufficient reason for making its period later than the age of the Austin chalk, were it not for other evidences found within a radius of ten miles. Proceeding in any direction instructive outcrops are found. One mile north (at C on map) Onion creek has cut its way through a great archway of this hardened chalk to a bed of ancient debris which must have been deposited by an eruption previous to the event that marmarosed the chalk.

This cañon of Onion creek is from fifty to one hundred feet deep and is formed by undermining erosion (Figs. 1 and 3).



Map of Austin, Texas, and vicinity, showing Outcrops of Igneous Rocks (shaded areas).

Its walls consist of (a) an upper layer of massive chalk or a metamorphosed chalk-bed, and (b) a lower softer portion of thin alternations of red, green and white layers. The alternations are the most remarkable features of all the phenomena for upon closer examination they are found to consist of volcanic debris mixed with shells of oysters (O. *læviuscula* Roemer, which is but the young of *O. ponderosa* Roemer) whose original shell matter is preserved without change from heat or other cause, and the casts of the

Inocerami (*I. umbonatus?*), the characteristic Inoceramus of the Austin chalk; showing that this preservation of fossil remains was by falling debris in their habitat.

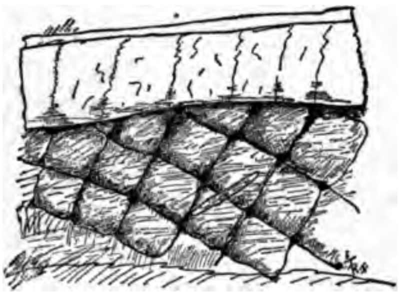


FIG. 1.—Contact of Chalk and Igneous Matter, with Limestone inclusion.

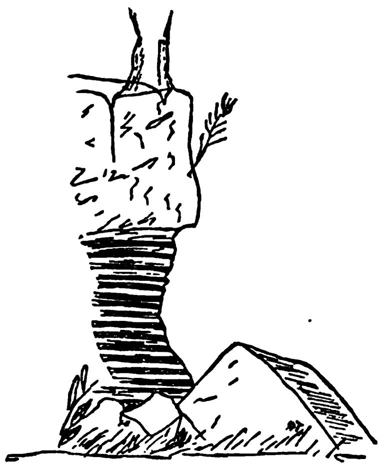


FIG. 3.—Alternations of Igneous Strata, with Fossiliferous Chalk.

The ashy layers are from one to six inches thick and alternate with layers of similar thickness of chalky but laminated material, showing there were alternations of deposition of volcanic ejecta in a molluscan inhabited ocean. Furthermore, as the species and chalk are deep water deposits, a rapid shallowing is inferred and as there is an absence of land debris and littoral fossils, the shallowing must have been insular and not continental. Hypothetically, this oldest record of Pilot Knob shows a rapid elevation of the ocean's bottom with its life from chalky depths to land, accompanied by many deposits of volcanic debris.

The knobs were probably the center of disturbance and the basaltic hills of to-day represent the neck of an ancient volcano whose crater has long since been denuded. Proof of this hypothesis is the increasing occurrence of debris as we recede from the knobs for four or five miles around. As shown on the map at E, F, G and H, the ash is found in greatest abundance towards the west and north. At Kunz station, four miles south of Austin, a railroad cut gives a fine exposure of this volcanic debris in close contact with unmetamorphosed chalk. It is a yellow and brown loose material, hardening on exposure, and contains occasional bombs of limestone (metamorphosed chalk) from a pea to a foot in diameter. About twenty feet of ash are here exposed and the bank is cut in two by a great fault which will be explained. Other beds of debris occur two miles west of Manchacha station, in Bouldin's creek, and in Fairview Park, South Austin. These exposures are made by the denudation of the Cretaceous chalks which covered them after their deposition. Superficial decomposition and the formation of zeolites followed.

Accompanying the exposures of debris are occasional strata of yellow or black-yellow crystalline limestones full of the fossils of the chalk. Thin slices of this limestone made by Mr. R. L. Ziller show olivine specks in the calcareous mixture, hence I incline to think it a mixture of chalky material and debris.

Structural Features Throwing Light upon the Age of Pilot Knob Activity.—The historic geology revealed in the sedimentary strata of the adjacent region is complete and by its aid the period of the activity of Pilot Knob can be determined. The intermingling of the earliest debris with the *O. læviuscula* beds and Inoceramus horizon of the Austin chalk shows that Pilot Knob was active during the latter half of the Austin-chalk sub-epoch of the upper Cretaceous period (about the Niobrara sub-epoch of the Northwest). The alternations of chalk and debris show long continuance of activity, while the great bed of chalk above shows a succeeding period of quiescence and subsidence.

The great faulting which the whole region has undergone since Pilot Knob's activity gives another proof of the age of the volcanic eruptions. The system of faults extend approximately north 20° east; several of them cut through the igneous material, as at Kunz Station, Onion creek and Fairview Park. The age of these great faults is later than the volcanic activity—is post upper Cre-

taceous, not Cretaceous, for the very latest Cretaceous strata are involved in their disturbance. These faults belong to the great Balcones system described by me in this journal, and whose line is followed by the I. & G. N. R. R. on map.

Tertiary and Quaternary History.—It is probable that the present topography of Pilot Knob and its crater-like weathering is the result of unequal resistance to atmospheric agencies and the whole area was once buried beneath Tertiary and Quaternary sediments. The original interior shore line of the stratigraphic features of Texas which are rapidly receding eastward is a question to be solved, but from the truncation of the dip planes and scarps of stratification, with the great thickness of the Neozoic terranes, it is evident that their former western margin except in rare instances was far west of its present position. Thus it was that both the great Cretaceous subsidences once covered the now denuded "Central Paleozoic region" of Texas, while the shore line of both Tertiary and Quaternary subsidences leveled the topographic features of Pilot Knob; for, several miles west of this extinct volcano, resting upon the western margin of the upper Cretaceous and against the Balcones scarp, as seen in Terrel hill on map, there is a distinctly preserved beach of the same post Cretaceous, probably post Tertiary, gravel which once covered Pilot Knob.

Relation to Other Areas.—Pilot Knob is but one of a score of igneous outcrops between Austin and the Rio Grande west of Eagle Pass, to which I have previously given the name of Shumard Knobs, but its exact relation to them has not yet been studied. It is in line with the igneous features of North Texas and southeast Arkansas. The general structural features indicate an affinity between them and suggests that together they constitute a line of igneous activity which once extended from the Ouachitas to the Rockies. It is interesting to note the proximity of this Cretaceous igneous outcrop to the Burnet granite. It is probable that this has been a region of intermittent activity since early Paleozoic time.

Conclusions.—From its structure it is shown that Pilot Knob is the neck of an ancient volcano which rose out of and deposited its debris in the deep water of the upper Cretaceous sea (probably Niobrara sub-epoch). From its isolated position remote from any contemporaneous shore line it must have been an island erup-

tion. Pilot Knob probably belongs to a great chain of igneous localities, eruptive and basaltic, extending from the mountains of northern Mexico to the Ouachita system of Arkansas, both of which regions abound in related features. The great Balcones system of N. 20° E. faults of central Texas are later than upper Cretaceous. In late Cretaceous, Quaternary and Tertiary times Pilot Knob was either totally submerged or greatly denuded.

Notes on a Nepheline-Basalt from Pilot Knob, Texas.

J. F. Kemp, Ithaca.

A selection of specimens representing various parts of the outcrop was forwarded for study. They are very dense, finely crystalline, of a dark gray or black color and resemble the usual run of compact basalts. Small lustrous grains, 1.0 mm. and less, are seen scattered through the mass and are shown by the slides to be olivine crystals. Amygdaloidal portions are found on the surface whose cavities are filled with calcite and probably by zeolites as well.

The rock is a difficult one to make transparent as the sections become merely translucent up to extreme thinness. It readily appears however under the microscope that the rock consists principally of a groundmass in which are set the phenocrysts of idiomorphic olivine and much smaller, brown, prismatic augite. The groundmass varies in character. At times under low powers it appears as a half opaque whitish mass which, in thin portions with high powers, is seen to consist largely of a very feebly refracting base, through which are scattered small microlites 0.01–0.02 mm. long and a quarter as broad, with an extinction angle of 30°–45°. These are probably augite. One or two small plagioclase microlites could also be recognized but they are extremely rare. The feebly refracting base gelatinizes readily and stains a deep tinge with fuchsine. On evaporating the gelatinous mass to dryness abundant cubes of sodium chloride separate out. From this the inference is drawn that the groundmass is essentially nepheline in a form approximating a glass, such as was named by Boricky nephelinitoid. Minute grains of magnetite are distributed everywhere through the sections. They average about 0.01 mm. The white, half opaque character of the groundmass may be due to partial alteration. Such a result is noted by Zirkel in vol. vi of the 40th Parallel Survey, p. 257, as occurring in the nepheline-

basanite from Fortification peak, Col., and in several European rocks of related character. Comparison with slides of the latter in the writer's possession shows quite analogous phenomena.

In other specimens the sections consist principally of a felt of brown augite needles 0.2 mm. long by 0.05 mm. broad, with a dark glassy material filling the interstices. The rock seems in such cases to approximate the limburgytes and to resemble quite closely a slide from the Hasenberg in Bohemia. The augites which gather in ocellar groups or nests are scarcely larger than those just mentioned and have the same brown color. They are abundantly provided with inclusions of magnetite.

The olivine is idiomorphic and exhibits most frequently the cross section that would indicate an original form with 2 P $\breve{\infty}$ strongly developed. A few included grains of magnetite are to be seen. Alteration is not usually far advanced. Where it seems to have reached its limit it affords a sphero-crystal of radiating needles, giving the usual interference cross. The dark grains scattered through the groundmass are all called magnetite above because they appeared in no case to be at all transparent and gave no indication of containing titanium. It cannot be stated therefore that either perofskite or chromite is present. An analysis yielded the following results from which it appears that the rock is very basic and of very high specific gravity:

SiO_2	38.35
Fe_2O_3	20.32
Al_2O_3	9.18
CaO	11.76
MgO	13.78
K_2O	2.02
Na_2O	2.77
Ignition	1.20
Total	99.38

Specific Gravity 3.211–3.223.

The rock is therefore to be considered a nepheline-basalt. So far as is at present known, such or allied rocks are not abundant in the United States, notwithstanding the great development of basalts in the west. Zirkel[1] determined one from the Kawsoh mountains, Nev. and others from the Elkhead mountains, Col., both of which contain plagioclase. Analyses given in vol. ii, pp.

[1] Survey of the 40th Parallel; vol. vi, p 256.

176 and 178 of the 40th Parallel Survey show them to contain from 10 to 15 per cent. more silica. Dr. Oscar Leow[2] has also determined a basalt with nepheline (nepheline-tephrite) from the Peloncillo mountains in Arizona, which like the others is far more acidic. The Texas rock also diverges widely from the tephrites and basanites described from the Crazy mountains, Mont., by J. E. Wolff[3] but it resembles closely so far as may be judged from the description, the nepheline-basalt collected by J. C. Branner in the Island of Fernando de Noronha and described by G. H. Williams.[4]

Geol. Laboratory Cornell University.

THE NORTH-EASTERN EXTENSION OF THE IROQUOIS BEACH IN NEW YORK.

By Prof. J. W. Spencer, Atlanta.

The barometer was used in the measurements of the Iroquois beach (Trans. Roy. Soc. Can. 1889) in the region of Watertown, New York, also the beach was not carried far eastward in that direction.

During last May I carried the investigation forward and used a proper level. The difficulty of following the beach was great, as in this region it is very frequently interrupted by the occurrence of rocky promontories, which existed in the body of water bounded by the Iroquois beach,—the result having been that no beach structure was produced in the very deep water in front of those old rocky points. Then, again the boulder clay of the drift is replaced by a stony drift sand. But with labor and the use of the level I have traced and measured the elevation of the beach to about 50 miles northeast of Watertown, and know its position for ten miles farther. The rocky islands in the Laurentian country of the northern Adirondacks further interfered with the work. The measurements were always on the summit of the beach barriers or spits, crossing the valleys between the promontories, making the accuracy of identification certain.

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[2] Wheeler's Survey, 1875; vol. iii, Geology, p. 647.

[3] Northern Transcontinental Survey. Notes on the Petrography of the Crazy Mountains, etc.; p. 8.

[4] Petrography of Fernando de Noronha; A. J. S. iii, vol. 37, p. 187.

The rise continues in a northeastward direction and, for the last forty miles (which were levelled) averages six feet per mile. Thus there is proved that no glacial dam existed in this part of the Adirondacks. Having traced the beach to an elevation of 972 feet above the sea, at a point south of Morrisburg (on the St. Lawrence), the measured warping is now sufficient to account for every foot of the rocky barrier across the basin of lake Ontario. This measured differential movement has been entirely since the episode of the upper till. This paper is intended only as a preliminary announcement, but the details will be eventually published.

THE RELATIONS OF THE STATE AND NATIONAL GEOLOGICAL SURVEYS TO EACH OTHER AND TO THE GEOLOGISTS OF THE COUNTRY.*

JOHN C. BRANNER, Little Rock, Ark.

The geologists of the country may be classified as follows:

I. Professional geologists, connected with the United States Geological Survey or with some of the state surveys.

II. Professorial geologists, or those teaching geology in our colleges and universities and sometimes making excursions into the field, either in the course of instruction or in order to carry on original investigations.

III. Consulting geologists, or those doing private economic work.

IV. Amateur geologists, including students who do volunteer work.

It is of the relations that exist, or should exist, between our national survey, the state surveys and the geologists of the country, in whichever of these classes they may fall, that I propose briefly to address you.

Investigations are often undertaken largely in the course of instruction carried on in college laboratories, but it is rarely that individuals or institutions other than the state and national surveys have undertaken extensive and expensive geologic operations. We must except, of course, in this statement those of an economic nature.

The reason of this is that individuals seldom, and commercial organizations never, devote their means to purely scientific investigations; and inasmuch as these investigations require large sums of money, and as they are conducted largely with a view to increasing human knowledge the expense of them must be borne by the public treasury.

With our official organizations most of the working geologists of the country, excepting those called consulting geologists, are connected

* Vice-presidential address before Section E, American Association for the Advancement of Science, Indianapolis, Aug. 20, 1890.

either as salaried assistants, permanent or temporary, or as volunteers. But these organizations carry on their work independent of each other, indeed without any regard to one another's existence, while individual investigators go each his own way pretty much as if he had the whole world of geology to himself.

If one has cause to be surprised at this lack of concerted action among men working upon the same and similar problems in the same country, we must remember that this state of affairs is the outcome partly of our democratic institutions and of our disposition to let every one shift for himself, partly of the great size of the country, and partly of the fact that there has never been, until recently at least, any attempt, or even any disposition, to bring all the geological material in the country into harmonious action and relations.

We have done better in this respect of late years, but there is still much room for improvement. If there has been but little coöperation hitherto among geologists and between official surveys, doubtless it is because, as Professor Brice says of democracy, "It takes many centuries to form those habits of compromise, that love of order, and that respect for public opinion which makes" good geologic work possible.

The United States Geological Survey.—The early geologic work carried on by the government in this country was done by military exploration parties under the War Department. Geology was in no case the prime object of these explorations, work of this kind being done by geological attachés of the parties. Geology came to be a more and more important part of them, however, until from 1867 to 1873 we had the surveys devoted principally to geography and geology under Clarence King and Lieutenant Wheeler, both of which were carried on under the War Department.*

In 1869 the Geographical and Geological Exploration of the Territories with Hayden as its director was authorized under the Department of the Interior, and in 1870, under the same department, the Geological and Geographical Survey of the Rocky Mountain Region under Major Powell was authorized by Congress.

The operations of these surveys seem to have been carried on to some extent without regard to each other, for a part of the work was duplicated, and jealousy was aroused to such a point as to become a scandal to scientific work in this country.

Looking over the evidence to-day it seems pretty clear that the United States engineers had resolved to drive out all other geographical work, and possibly all geological work, from a field which they felt to be their own, for they seem in all cases to have been the aggressive parties. This issue being forced upon Congress, in 1878 the National Academy of Science was asked to appoint a committee "to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office, and to report to Congress as soon thereafter as may be

*A list of the commanders and the dates of these expeditions is given in Ex. Doc. No. 240, 43rd Congress, 1st Session, pp. 6-8.

practicable a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost."

This committee of the National Academy of Science was appointed and made the required report. It recommended that the surveys then in existence should be discontinued, including the Land Office surveys, and that there should be a single national geological survey which should deal with geologic problems, and that all mensuration should be done by and under the Coast and Geodetic Survey, which should furnish whatever maps might be wanted.

The action suggested regarding the Coast and Geodetic Survey was not taken, but Congress discontinued the old geographical and geological surveys and the United States Geological Survey was established in 1879 as a permanent bureau of the Department of the Interior.

In the reorganization of the national survey after the extinction of the old surveys most of the men from all the former institutions were retained. This is where we find ourselves to-day with our United States Geological Survey.

It is not necessary that I should speak of the functions of this national survey as defined by law, for in a general way you are all familiar with them, while the business organization and general plan of carrying on its work is set forth in the eighth Annual Report of the Director. Practically it has *carte blanche* to carry on geologic investigations over the whole territory of the United States, and in every branch of scientific work directly related to geology, such as geography, topography, paleontology, physics, chemistry and statistics.

Now over this same area, though limited to the states carrying them on, we have our several state geological surveys; while private individuals, educational institutions, scientific societies and commercial corporations are at liberty to carry on such investigations as they see fit, and all regardless of each other.

It would be very natural to expect that there would be more or less serious conflict between organizations and individuals working, as these do, upon the same questions and over the same areas.

In the earlier work carried on by the federal government, however, the various territories were the specified areas to which the national surveys were confined, and now that the whole area of the United States is open to this work, a broad-minded and coöperative direction seeks to aid and strengthen the state organizations instead of antagonizing or annihilating them.

But I wish to emphasize the fact that the classification of the geologists of the country, the work within the domain of the national survey, the work within the domain of the state surveys and that which can be, or will be, accomplished by private institutions, corporations or individuals demand that there should be some more definite or better organized coöperation or coördination in all this work and among all these men.

The success of commercial and industrial enterprises the world over has been due to a greater or less extent to concerted action. In educa-

tional matters where action has been concerted and efforts and means concentrated there have our most marked successes been. Geologists may disregard the advantages to be derived from such coöperation, but it must be at their own expense and at the expense of the science.

And without doubt one of the reasons that coöperation has not been further practiced than it has been is that a sort of antagonism between older organizations has been handed down to us, and also because it takes time to bring into harmonious action a large number of men scattered over a vast territory and variously interested in widely different phases of geologic problems.

The statement has been made that the United States Survey does coöperate with very nearly every state survey in the country, but the fact is that the national survey does not know what the state surveys are doing except in a very general way, and that the state surveys know but little or nothing of what the national survey is doing, except perhaps as it may happen to be picked up in private conversations and in private correspondence between personal friends.

Please bear in mind that this is not intended as reflecting upon the Director of the United States Survey; coöperation can only exist by the common consent of all the parties concerned, and it is quite as much the fault of the state surveys that there is no such coöperation as it is that of the United States Survey.

I might cite the case of a state survey of which I have some knowledge where the national survey carried its topographic work forward without any reference to what the state survey needed, for it didn't know the state survey's needs, and when, almost by accident, the state survey learned of the government work, that work had gone too far to be modified to suit the needs of the state survey.

When I found myself a state geologist and began to look about me, and when I saw the relation in which a state survey stands to the national survey, I confess that I felt very much as the cock did who was put in the stable with the horse. The cock sought to get on a proper footing with his companion by saying, "Now, let's not step on each other," and if I didn't do likewise, it was not because I didn't see that I was as completely at the mercy of the United States Survey.

I mention my own case partly because I know more about it than any other, and partly because I am responsible to a great extent for the absence of intelligent and economic coöperation in the work done in the state of Arkansas.

The conclusions which I have reached, then, in regard to the relations that exist and those which should exist between the surveys and the geologists of the country are the result of my own experience and my own convictions, confirmed by the experience and convictions of others—and that is that we should come to some understanding about what each one shall do and shall not do.

What I have to say, however, refers to the internal arrangements and the working of geologists as affected by our own bearing toward the official surveys, toward each other and towards the science, rather than

towards official relations and toward legislation. For these are not matters to be fixed by laws; laws would interfere with that freedom of movement that gives health, vigor and activity to our scientific bodies and to our scientific men; they can only be determined by common consent and by usage.

To begin with there should be some unanimity among all geologists about the scientific standing of our government and our state surveys, and about what each one can do and ought to do.

First in regard to the United States Geological Survey:

This institution stands at the official head of all our surveys and of all our geological work.

Every statesman recognizes the fact that science is an element of prosperity and power which it is the duty of the state to foster just as it should foster other elements of progress and civilization, and it should fill every geologist with the profoundest gratification that our statesmen realize the importance of the general government's giving liberal support to geologic work.

We must all of a necessity take a deep interest in the organization and conduct of this, our national survey, for the work to which it is devoted can only be done by aid of the government, and should that aid fail, either on account of proper organization or inefficiency, or on account of jealousy, or for any other reason, the progress of the science of geology in this country would be seriously impeded if it did not come to a dead halt.

We have reason also to congratulate ourselves and to congratulate the country that since its reorganization in 1879 there has been in the directorship a geologist in sympathy with all branches of scientific work, and at the same time a man who does not shirk his duty in the survey's relations to Congress.

Not a few scientific men have false notions of their personal and professional dignity when these affairs crowd upon their attention.

We need only remind ourselves that appropriations are quite as essential to geologic work as workers are, and that this part of the business can no more be neglected than any other part of it.

Just think where we should have been if no efforts had been made to lay the truth before legislators. Congressmen are busy men, too busy to go out of their way to look up worthy institutions that need support. All that enlightened statesmen want to know are the needs, demands and uses of these surveys, and they will see that they are properly supported; but how are statesmen to get this information if some well-posted geologist doesn't furnish it? Statesmen must depend on geologists for such information as will enable them to act intelligently, and it is as plainly the duty of the director of the United States Survey to inform Congressmen and Senators of the needs of geologic work in the country as it is to carry on the work itself. It is a duty he owes to the people and to science.

National work encourages and stimulates state work, and state work

reacts in favor of national work, and both stimulate private enterprise and investigation. The return from all this no man can measure, for it is both material and intellectual, and in both these senses it is felt in every nook and corner of the land.

The national survey is thus doing a work that no other institution can do, and it is able to maintain an organization of geologists that no other institution could maintain. For nowhere, in no country, is there, and at no time has there been, a corps of working geologists superior to that of our present national survey—a body of geologists, of which every scientific man and indeed every citizen of this country may well be proud.

Having no connection with that organization, either present or prospective, I feel at liberty to express a frank, disinterested and independent judgment.

And I take the liberty to express the conviction just here that no more amazing thing can be found in the annals of science than that there are geologists—men who claim to be interested in the advancement of science—who would be glad to put an end to our national survey, the institution that has, as it were, laid the golden eggs of geologic science in this country.

The National Survey and the State Surveys.—With this splendid equipment of men and of means, what can the National Survey best do and best leave to state surveys and to private enterprise? The question is not asked as implying that the officers of that body are not perfectly competent to decide these matters, but because we feel that a more effectual coöperation can be brought about to the great advantage of every one concerned. So long as more than one organization must occupy the same field, some understanding can certainly be arrived at that will prevent the duplication of work and the waste of energy and of funds.

The appliances, libraries, laboratories, equipments and the large number of special assistants required by a national survey are quite beyond the means of our modest state surveys.

The great size of our country, the wide sweeping character of its general geologic structure, and the limits placed by civil boundaries on state work must throw most of the important general questions into the hands of the national survey. Local details can and should be worked out by the state surveys, and these results should be placed as soon as possible at the disposal of the specialists of the national survey. It is self-evident that problems that can be solved only after a wide experience and acquaintance with the whole country cannot be satisfactorily undertaken by the state surveys, but that they must be solved by the larger and stronger organizations.

There are certain classes of work that, of necessity, fall upon a national rather than upon the state surveys; such are triangulation, precise levels, topography, paleontologic work, almost all investigations falling under the head of what is usually known as pure science, and all

those investigations requiring much time and labor and money and many specialists. The reasons why state surveys cannot do work of this class are not far to seek: The men with whom the national survey has to deal are our broadest-minded statesmen—men who comprehend the scope and importance of purely scientific work, while, as a rule, state legislators look to immediate, and what they call practical, results. Such men cannot be convinced of the importance of any work that looks not to the immediate material prosperity of the state, while they are but little concerned, as a rule, with the intellectual income from it.

It is entirely beyond the means of any state survey to make a topographic map of the entire area of the state; the best it can do is to select a few typical areas and map those. But maps are absolutely essential to satisfactory geological work, and map-making has come to consume a constantly increasing share of the money appropriated for geological surveys, both state and national. The national survey, however, having large appropriations for topographic work, and contemplating as it does the mapping of the entire area of the United States, ought to do this work.

That these maps must meet various demands and must therefore be constructed with varying degrees of accuracy and detail every one will admit. As a matter of fact, however, the maps made are usually, as they should be, parts of a plan, and upon a scale, for mapping the whole of the United States. This plan and scale may be perfect for that particular purpose, but it often happens that neither the plan nor the map is adapted to the purposes of the state surveys. And certainly nothing can be plainer than that the maps made by a geological survey ought to be available for geological work, or that, failing to meet the demands of geology, there is no geological excuse or reason for their existence.

Take for example the topography of the glaciated area of the Mississippi valley. The region is one of but little relief, and, in order to bring out this relief, the contour intervals must be very small. But the contour interval on the U. S. Survey maps is 50′, one that completely ignores the delicate topographic character of the glaciated area of the Mississippi valley.

It follows therefore that the plan for topographic maps should be sufficiently flexible to meet the demands of those by whom and the purposes for which they are to be used.

Geodetic work cannot be carried on by the states because states are but small parts of, and furnish but a few points in, geodetic questions. European countries have even been obliged to unify their work. In the United States work of this character must be left to some institution of the general government.

That paleontologic work should be relegated to the national survey seems to me scarcely to admit of question. The reasons for such assignment are briefly as follows:

I. It is a piece of purely scientific investigation, the importance of which state Legislatures as a rule do not comprehend.

II. The investigation demands a knowledge of the fossil fauna of not one state alone, but of a great many states, and often of the fauna of all the explored rocks of the earth, while the observations limited to a single state are sure to lead to duplication and to erroneous conclusions.

III. The work can be properly done only by specialists which state surveys cannot afford to employ.

IV. The illustrations necessary in a paleontologic report are too expensive to be paid for out of the modest appropriations made for state surveys.

It might be urged against these reasons that the states of Illinois and New York afford striking examples of the fact that states may and can and do carry on a high grade of paleontologic work. But it should be remembered that the conditions under which these excellent results have been obtained have passed or are about to pass away. For while the states of Illinois and New York have grown in wealth and intelligence since their surveys were begun, the legislatures of those states could not to-day be induced to take up and carry forward works of so purely a scientific nature, and if those states could have seen the end from the beginning, it may well be doubted whether they would have undertaken the great paleontologic investigations carried on so long and so successfully by Hall and by Worthen.

Another point which I must insist upon is, that it is the place of a state geological survey to do what is wanted in the state, and as a rule economic results are wanted. The people are entitled to what they pay for. Not that the survey must go on every wild-goose chase suggested, and examine every prospect and claim in the country, but the problems which the people wish to have solved should be solved if they can be. These very demands define the work of the state surveys and separate it pretty sharply from that of the national survey.

If we are to be perfectly honest with ourselves we must confess that the state surveys have, as a rule, failed to do what the people have expected of them, and one of the principal reasons for these failures is that the geologists have not had the counsel and the coöperation of a national survey. The geologists who have encouraged the making of appropriations for the work have invariably held out the hope that these surveys would be devoted to economic geology, while members of legislatures who have supported such bills have invariably done so in the expectation that they would do something of direct economic importance. But there are but few exceptions to the rule that these state appropriations have been devoted to paleontologic problems and to pure science, while economic problems have been entirely lost sight of.

These economic problems, or such of them, or rather, perhaps, such phases of them as can safely be dealt with by the state, should be the special province of the state survey, while the broader questions which can be satisfactorily studied and safely discussed only over wide areas should be left to the national survey.

It is true that economic and purely scientific problems cannot be entirely separated, and there is no necessity that they should be, but geo-

logic work may give preference or prominence to one or to the other phase of the question as the case may demand.

Some geologic problems naturally precede others, and if we work intelligently, we must take up these problems in their logical order. But in state work this is seldom possible, for state geologists must do their work in an order made necessary, not by geology alone, but by some economic consideration it may be.

I have said that economic problems should, in so far as possible, be left to the states. There are cases, however, in which this cannot be done, for there are often those which, requiring study over a wider area, cannot be solved in a single state. These should be studied in part or entirely as the case may demand, by the national survey. Take for example the lead ores of the country; these ores occur in several states, and in each case it may be under somewhat different circumstances. Now the study of the origin and distribution of lead ores should be taken up as a whole, and not simply as a local question, for it cannot be satisfactorily studied and discussed in any single place.

If geology is studied as it should be the student must be at liberty to move about as the exigencies of his work demand. This is not permitted by state surveys, and even if the employees of a state survey felt themselves at liberty to travel over the country studying the questions with which they have to deal, they haven't appropriations large enough to admit of the heavy field expenses required for such work.

Take again the subject of glaciation: how would it ever have been possible for any one, confining his observations to any single state, to have formed an opinion or to have reached a conclusion regarding glaciation worthy of utterance. And I venture to say that if there is still a good deal to be learned before we shall fully comprehend the history of the continent during Pleistocene times, it is due to no small extent to the fact that our observations have not yet taken wide enough range.

To be sure there is local work enough on this subject and to spare, but the great question as a whole could never be comprehended, stated, studied, or solved in any single state, or indeed at all unless one had *carte blanche* for his movements.

Professor Irving has well remarked:* What "countless, interminable wranglings as to stratigraphical correlations in the states east of the Mississippi..might have been prevented had any one geologist been able to follow through its whole extent the formation he was studying." But the state geologist is stopped by state boundaries, and the broader questions of stratigraphy and correlation cannot be settled or even satisfactorily discussed by him.

It seems plain that in so far as the relations between the national and the state surveys are concerned the national survey should leave all that it can safely leave to private enterprise and to state surveys, and that it should deal with those problems which state surveys and individuals will not or cannot satisfactorily deal with.

*The School of Mines Quarterly, Vol. IV, No. 4, June, 1883. p. 288.

It is my opinion also that the national survey, being better informed of what is going on in the way of geologic work than the state geologists, and being in every respect the strongest of our organizations, should hold out a helping hand to the state surveys, and from their wider and more valuable experience, give advice and encouragement to state work. In this way state aid to scientific work would be encouraged and the national survey would widen its helpful influence.

It goes without saying that state and national surveys should not ride rough shod over each other just because there is no law to prevent their duplicating each other's work or their doing work that will interfere with each other's plans or efficiency. It would be easy for a government survey to discredit and embarrass a state survey to such a point that the state would put a stop to its own work. Fortunately our national survey has been conducted rather with a view to aiding the state surveys. But this aid can be made much more effectual than it ever has been, and I have no doubt it will be made so whenever we are all ready for such coöperation.

The United States Survey and the Colleges.—My own conception of scientific organizations is not that they should simply devote themselves to the accumulation of scientific facts—to research—but that they should at the same time encourage and develop scientific men.

They should have much to do with the training of geologists in proper methods. It will not cost much, and it will look well, and the few efforts required by such encouragement must yield valuable results in the future. Geologic investigation should, therefore, in so far as possible, aid and encourage instruction.

Work is often needed in the vicinity of colleges in order to have it available in instruction, and the national survey should see that this work is done—in other words, it should coöperate with the professor in charge, giving what he needs, and obtaining in return such contributions as he can make to local geology.

Geologists are sometimes modest men. It is the duty of the national survey to look these modest men out, and to encourage and help them and to make them feel that they are a part of the geological body of the country. It should see to it that there is no geological ground left uncultivated.

Coöperation.—If a cordial coöperation could be brought about between all the working geologists of the country there would be more satisfactory progress all along the line. This is made necessary by the number of geologists in the country, by the country's vast area and by the conservation of energy and of funds.

Imagine a number of men working, a few under organized direction, but a large number independently, and with no responsibility to any one, for the purpose of erecting a large edifice. Those who direct have in mind all the specifications: they know what kind of material is wanted and how much, and where it is needed. Those who bring and prepare this material use their best efforts—they labor in love and with the inspiring hope that they are contributing something to this great

building. What must one's feelings be when he brings his contribution to find that it is in the wrong place, or that it is not wanted? Mistakes of the same sort are constantly being committed in geologic work and in abundance too, all because we have no recognized directing head for the work done outside of the United States Geological Survey.

The bulk of geologic literature must yearly become greater, and unless it becomes at the same time better, we must expect a day to arrive when geologists may well stand appalled before it. Much of this literature is practically worthless; it is an encumbrance rather than a help to the progress of science, and we should feel grateful to any method that would deliver us and geology from an evil which is coming to be a more and more serious one.

In one of the states in which the United States Survey has been doing topographic work, an area of 3,000 square miles that had already been surveyed had to be remapped by the state survey to meet its own demands. Here I think no one will have any difficulty in understanding the necessity of coöperation between the state and the national survey.

Take as another example the chemical analyses made for geologic purposes. The chemists of state and national surveys have thrown upon them a vast amount of heterogeneous work, while but little or no time is left them for original investigations. A great many of their analyses are duplicated elsewhere, or may be duplicated in any number of laboratories, so that investigations that might otherwise have been possible are prevented, and both chemistry and geology are hindered.

The errors committed by geologists not connected with the surveys are mainly due to haste, or in other words, to expression of opinion based upon too limited observations. But only limited observations are possible to men of limited time for the work, and limited means to work with, a limited area to work in, limited acquaintance with field geologists, and limited opportunities for publication.

There are many young geologists and men of but little experience—amateurs—whose efforts are not so directed as to be of as much service as they might be. They lack neither zeal nor means in many cases, but they do lack some one to guide their tottering footsteps. Their want of experience gives them but a restricted view of the field in which they are laboring. Their labors cannot therefore, unless directed by some one who has a sufficiently broad view of the whole field, be of any value to geology. Who will direct them? Or shall they go on piling higher their wasted energies, and find themselves when they have come to the end with the mortification of knowing that though they have worked hard and faithfully, they have in reality contributed nothing to the sum of human knowledge?

So our energies are not fully utilized; we are like a great system of machinery with here a bent shaft wasting the greater part of its energy in friction, there a broken belt that has stopped a useful machine, here a timber caught in the wheels and beating the walls and floors.

If we could have some sort of coöperation, a man at work upon a particular subject would have some assurance that his field of operations

would be, within all reasonable limits, left to him. As matters now stand a geologist is often obliged to mount guard over his own grounds and in his own work to keep the unscrupulous camp-followers of science from walking off with and getting the credit for the results of his labors.

Coöperation would enable each one to concentrate his efforts upon that line of work or that investigation in which he is especially interested. As matters have gone heretofore no state survey and no man on a state survey has been able to take up any one subject in a systematic and thorough manner unless it has happened that some one group of facts has been available in his own state alone. Take any topic you may choose for a test and you will find this to be an invariable rule.

Do the best we may, there is not one of us who may not be benefited more or less by friendly criticism. And it is of great importance to the science that these criticisms be made before our results or observations are published. In this way we may avoid adding to that vast talus of geologic trash beneath which the science of geology is buried more and more each year. Such criticism is not possible except under conditions that enable us to know the lay of the land with reference to other geologists and to what they have done and are doing.

It should be distinctly understood from the outset that such work is to be, not subordination, but coördination and above all coöperation. The demands of scientific work do not require and the conditions and peculiarities surrounding scientific ambition and devotion do not admit of the most successful and satisfactory work being done in a perfunctory manner.

I would not by any means destroy the autonomy of local societies or of independent workers not formally connected with the public surveys. Certain independence of thought and action is essential to scientific advancement, and friendly rivalry is not only not injurious, but it is extremely helpful, and in many cases absolutely essential. But such an organization of geologists would have to allow and even encourage this independence.

Every man should be held responsible for his own work, and, in this way, made to retain the sense of personal responsibility. This plan of coöperative action, in order to be successful, would require that in the work accomplished there should be the fullest recognition for each man's contribution. Workers in science will not be found willing to make of themselves parts of a great piece of machinery which entails the loss of their individuality. They must have the fullest credit for all they do. At the same time one must not try to get all the good he can without giving something in return.

I have no idea that a "perpetual motion" sort of a geological machine can be devised, or that any arrangement or adjustment of parts is possible which will entirely do away with friction.

It is scarcely possible that any devise that can be made or suggested would be perfectly satisfactory, but it certainly is reasonable to expect that some system of coöperation can be devised and put into practical

operation. If ever such operation should be brought about, several points must be kept in mind by us all.

There must be a certain amount of elasticity in any plan that may be adopted, for geological investigation like any other investigation leads us off on many unexpected tangents.

Subordination would have to be largely nominal, for those who do the best and most work would have to take precedence of those who did not so well.

As much latitude as possible would have to be allowed individuality. Men are not like pieces of coal to be separated and classified by sizes or by specific gravity.

Administrative methods devised for scientific work, like those of diplomacy, are often a series of compromises, and good sense must make up for the defects of any system.

No plan of coöperation can succeed if we do not all take a broad and unselfish view of science and its functions; we must work for its advancement; and the idea of putting a caveat on this or that topic must be relegated to the dark ages of geologic science.

Men will be ready to coöperate with us the moment they are made to feel that their contributions are useful and are appreciated, and that they will not lie unattended for years in the hands of some one not impressed with the shortness of time and of human life.

In order to have coöperation each one must do, in addition to the direct objects of his work, what others want.

Local talent should be utilized. It would in many cases save a good deal that now goes to pay travelling expenses, to say nothing of the importance of keeping all the geologists of the country actively interested in geologic work.

A working geologist, if he works intelligently, must know and keep in mind what other people are doing; and he certainly cannot do this if he is working alone, and without any recognized relations to other geologists.

Now if geologic work can be improved by being under the nominal direction of those best fitted to direct, where are we to find our directors? The men who have done most to popularize the science of geology in this country are our professorial geologists, and it is not unnatural that we should turn to them. But the teachers of a science are not necessarily the best directors of research, while they are probably in no case thoroughly conversant with the work being done by the various state surveys and by the national survey.

The direction of work over the whole country would be quite as impossible, or even more so, from the states.

The national survey, standing as it does at the head of all the geologic work done in the country, having the whole national domain as its field, and composed as it is, of our best geologists and having the most thorough organization, is, or should be, the natural head and director of all geological work in this country. I have no doubt that the

national survey would be glad to help in so far as it can to unify and to give useful direction to this work.

I take this ground in the face of the statement of the distinguished Director of the United States Geological Survey who has said that "all of this scientific research under national, state, and local patronage, cannot be controlled by some central authority, as an army by its general, from the fact that scientific men, competent to pursue original research, are peculiarly averse to dictation and official management. Scientific men spurn authority, but seek for coördination."*

The function of a director or of a superior, in science at least, is not, to be sure, that of a commander ordering here and there men who must simply obey, who must have no independent opinions or plans of their own; he must rather be a helper, a man to encourage, to suggest, to fire with enthusiasm those under him and to unify the work of the organization of which he is the head. Scientific men do not spurn authority if there is any reason for it, and as a proof of it we may cite the United States Geological Survey itself, as well as all the state geological surveys in this country, or for that matter, in the world. The members of all these surveys submit to all reasonable authority, but they are also put upon congenial work, and they are permitted to do that work pretty much in their own way. Now why can there not be an organization of all geologists more or less similar to this?

We may disabuse our minds of the thought that there is a probability or even a possibility of the government monopolizing geology. It can't do it; geology belongs to the geologists, whether the government helps carry on geologic investigations or not.

Conclusions.—My conclusions are:

First: that the great and valuable contributions to geologic knowledge must be made by our official surveys, for they alone have the means for producing them—for gathering the facts, giving the necessary time to philosophical thought and discussion, and for furnishing the necessary illustrations, and for making and distributing the publications.

Second: that economic problems should be left, in so far as it is possible, to the state surveys, while the national survey should deal with those requiring larger means and a wider range of observations.

Third: that all the working geologists of the country should be brought into official or quasi-official relations with the state and national surveys and their efforts and skill thus utilized.

I am free to admit, however, that no plan of operation or coöperation can be devised that will work to the complete satisfaction of everybody. We sometimes have men to deal with who are not amenable to either law or reason.

In his presidential address before the American Association at Cleveland professor Langley compared the advance made by scientific men in their search after truth to that of a pack of hounds following a trail.

*Testimony of Major J. W. Powell; Organization of Certain Bureaus, Mis. Doc. No. 82, 49th Congress, 1st Session, 1884-5, p. 178.

Permit me to carry this simile still further. Hounds understand that it is their business to follow the game, and, when left to their own instincts and wishes, they will follow it. Now imagine a bull-dog seized with the ambition to become a hunter and joining the pack of hounds. Every one knows that the bull-dog will, in spite of anything that can be done, have a fight with half a dozen, or, more likely, with the whole pack of hounds, by the time the chase is well under way.

It is not a pleasing reflection to remember that the great search after truth in which every genuine man of science is engaged, heart and soul, is often interrupted in this same fashion by the pugnaceous disposition of some companion.

Let me recapitulate some of the benefits to be derived from voluntary and cordial coöperation between all geologists and all geological organizations in this country:

I. Geologic research being under the nominal direction of the leading investigators would be so conducted as to be of the greatest utility to the largest number.

II. When a piece of work was done by one it would be done for all, and duplication by state surveys and by individuals and the consequent waste of energy, time and money would cease.

III. The functions and fields of official organizations being better defined, state and national surveys and individuals could so direct their efforts as to serve the purposes of others without neglecting their own immediate aims, and without infringing upon each other's grounds.

IV. National and state surveys would be strengthened and local organizations and individual efforts encouraged.

V. It would give us a better geologic literature, better instruction, better geologists and more thorough specialists.

VI. And finally, we trust, it would put a stop to those oracles who are so ready to prophesy in the name of science.

The comprehensive character of geology requires us to draw upon many cognate branches of science, and successful coöperation among geologists would also react in favor of those sciences, for we need not only the coöperation of the geologists of the country, but that of the engineers, the miners, the meteorologists, astronomers and chemists.

This ideal state of affairs may never be brought about, but it is none the less desirable that we should aim at it; for the more nearly we approximate to it the more rapid will be the progress of science, and the progress of science is the progress of civilization.

To paraphrase a recent utterance of bishop Potter, "It would be a monstrous conception of science if any one of us were to esteem it only as a selfish weapon with which he was to carve his way to personal fame and fortune."* It has often been used for just that purpose, but higher ideals will give us nobler motives.

*Phi Beta Kappa Address at Harvard, 1890.

EDITORIAL COMMENT.

QUEBEC NOT IN CONFLICT WITH TACONIC.

In a late paper on the "Quebec Group of Logan," published in the July number of the *Canadian Record of Science* (Montreal), by Sir William Dawson, it is clearly pointed out that the essential idea of Sir William Logan in the creation of the Quebec Group was to apply a name to a series of strata having "a great development about the horizon of the Chazy and Calciferous," and that the name is still needed for convenience of use and because there is absolutely no other designation to this day that can be made to include them as a group. In the group so designated should be placed that series of alternating magnesian limestones and sandstones (containing conglomerates in the eastern part of America) well known in the Mississippi valley, extending from the base of the Trenton limestone to the red sandstones at the top of the Keweenawan. In Vermont it has recently been shown by Brainerd and Seely that these strata have a great development. Mistakes which Logan, or others, may have made in defining the geographic extent of this group, or in supposing it to have been metamorphosed into crystalline or sub-crystalline terranes (such as the copper-bearing series of lake Superior) should be eliminated, but these mistakes, as argued by Sir William Dawson, should not be allowed to vitiate the conception which gave origin to the term.

"It may be said that the same arguments would necessitate the retention of the Taconic system of Emmons. To this I have not the slightest objection, provided that the same rule be applied to it: namely, that it be taken on Emmons' own definition, and without including rocks or fossils referred by mistake, either by him or by others, to the horizon so defined.

"In his *American Geology*, 1855, Emmons says (part II, p. 6) that in 1836 he had regarded the Potsdam sandstone as 'the base of the Silurian system,' but that he had since found 'the same base resting on sediments still older.' These he called the Taconic system, and defines this as a fossiliferous group under the Potsdam, and itself 'found to rest upon Primary (that is, crystalline) rocks.' Thus his Taconic of 1855 is clearly the middle

and lower Cambrian, of modern geologists, and the fossils which he attributes to the Taconic are in great part of this age. That in the subsequent pages of his book in tracing the Taconic through the complex structure of the districts in which it occurs, and enumerating its fossils, he mixes other formations with it is most true. But fair critics of Emmons would do well to eliminate these errors, and leave him the credit of his discoveries in those pre-Potsdam rocks, which, though different in age from the Quebec group, are like it, in the main, a marginal Atlantic series, not represented in the central plateau." (p. 139).

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Iroquois Beach: a Chapter in the Geological History of Lake Ontario. By PROF. J. W. SPENCER (Trans. Royal Society, Canada, 1889). Nine or ten years ago Dr. Spencer published his first paper concerning the origin and history of the great lakes. Since then several papers have appeared. But the paper before us is somewhat lengthy and considers the greatest development of lake Ontario, but does not delimit the northeastern margins of the old lake, as researches had not been sufficiently carried on in that direction.

The paper is based upon a great beach representing the only long episode in the history of lake Ontario, between the time that it became a separate lake and the commencement of the formation of the modern beach. The structure of beaches is touched upon, as well as boulder pavements. These questions are, however, more fully treated in "Ancient Shores, Boulder Pavements," etc., a paper appearing in Bull. Geol. Soc. Am., vol. i. The materials of the beaches about the lake (except towards the northeast of the ancient lake margin) are mostly derived from the boulder clay, which generally formed the shores of the old lake, or from modified drift.

The beach is no longer a water level. At Hamilton, at the extreme western end of the lake, the beach is 116 feet above its surface. Upon the northern side, this elevation increases until near Trenton (about 130 miles distant) it is found at a hight of 435 feet. From near Trenton the beach swings around towards the Ottawa river, and has been too imperfectly followed to give absolute results. All of the author's measurements were instrumental levels, except in northern New York, where the barometer was provisionally used.

Upon the southern and southeastern sides of the lake the measurements were those of Mr. G. K. Gilbert. In the eastern direction, upon

the southern side of the lake the rise is less marked, the beach being at Canastota (southeast of Oneida lake) 192 feet above the lake. But thence northward it rises rapidly to 450 feet near Watertown. The deformation here recorded in a large measure explains the rocky barrier across the St. Lawrence outlet, compared with the depth of the lake.

The question of connection with the sea is considered. Combining the warping of the Iroquois beach with that recorded in the beaches of the upper lakes traced all the way to lake Michigan by the author, it is seen that the Ontario sheet (called lake Iroquois) was at sea level during the time of the formation of the beach. It is regarded as like the gulf of Obi, which has similar proportions with the old lake and its continuation in what is now the St. Lawrence valley, with the water probably fresh in the upper portion of the basin. The question of glacial dams for holding the water is regarded as an impossible feature under the conditions, and indeed such ought not to be laid down until the eastern extension of the beach is proved to be absent.

The formation of this high beach commenced at the same time as the Niagara river, which the author places roughly at 26,000 years, based upon the mean known rate of recession (which would make it 15,000 years had the fall of water between Erie and Ontario been that of the present day) and the then inferior descent of the waters of the Erie basin causing the erosion to have been less rapid than now, which would lengthen the time far beyond the 26,000 years, but which would be reduced by various complex causes.

The paper is illustrated with a map and various sections.

Nicholson and Lyddeker's Palæontology.—The size and growth of this work are an index of the growth and extent of the young science of palæontology. Dating back no farther than the epochal work of Cuvier on the fossils of the Paris basin it has grown so rapidly that it now presents to us a sketch of the life-history of the globe. Recent zoölogy, once its superior, is rapidly falling into place as only a transitory stage in the long story of animal existence. Palæontology, however, is divided into two branches—palæozoölogy and palæobotany, and the present work deals chiefly with the former in the various departments of which the two distinguished authors have long been persevering and successful workers. Perhaps it would have been as well if they had yielded to their own suggestion and confined their labors to this side alone, omitting altogether the subject of palæobotany. That they felt impressed in this direction is evident from their preface where they say:

"Fossil plants have been dealt with after a somewhat summary fashion because palæozoölogy is of greater importance to the general student than palæobotany, and because the latter subject is one of great complexity and one on which neither of the authors has any claim to speak with authority."

In their introduction the authors have given an excellent chapter on contemporaneity, pointing out the distinction that should be made between it and homotaxis. This has often been brought forward, but is

constantly overlooked. Huxley called attention to it many years ago by remarking that exact resemblance between two distant faunas was proof that they were not contemporaneous, inasmuch as there must have intervened sufficient time for migration from one place to the other. Such deposits are, however, homotaxial, because they represent the life of corresponding eras in the two regions. The comparatively small difference in date becomes almost infinitesimal by the side of the immense distance that sunders them both from the present. Geologists are apt to lose sight of the former in their strong appreciation of the latter.

Another chapter treats of the continuity of life, a subject on which no geologist now entertains any doubt. The catastrophes of the earlier investigators such as E. de Beaumont are as dead as their authors, and the remaining gaps in the record give us no anxiety.

The discussion of the doctrine of "colonies" is of great importance. It is well known that the late M. Barrande announced his belief that whole groups of species appeared in a local and transient manner at certain places before appearing as an established fauna. Thus he maintained that Silurian species could be found in spots in Bohemia among Ordovician (Lower Silurian) strata, and that the alternation occurred several times before the permanent establishment of the later fauna took place. Now while there is little difficulty in accepting this doctrine if confined to species differing but little in age, it has been difficult to admit the alternation or simultaneous existence of faunas so widely distant as the Ordovician and Silurian. Only the high authority of Barrande could have given it the currency that it has obtained. Our author is evidently in favor of accepting the view of Mr. Marr that these seeming colonies are only results of repeated faulting-down of Silurian among Ordovician rocks. In this case the seeming difficulty is removed and the so-called "colonies" have no existence.

In the chapter on the imperfection of the geological record the argument originally put forward by Darwin is developed with great force and clearness. The author shows that the want of hard parts is one of the chief causes of this imperfection and brings in evidence the fact that in the various groups of the animal kingdom those families are, on the whole, abundantly represented whose living species possess hard skeletons. Thus among the rhizopods, the Amœbea and Monera are missing from the rocks, but the foraminifers and radiolarians (at present calcareous and siliceous) are exceedingly abundant. So the Myxospongiæ (soft) are absent, but the Porifera (hard) abound in the fossil state. Likewise the hydras and medusas, the sea-anemones and ctenophores are wanting, but the corals, graptolites and stromatoporoids compose vast masses of rock. Other similar cases are cited.

Views on geological climate are expressed with great caution. In the present conflicting state of the evidence this is the only wise plan. Eminent geologists and physicists so widely differ in opinion that no confidence can be felt in any positive statement.

The composition of the work has been divided between the authors in accordance with their palæontological pursuits for many years past.

Prof. Nicholson takes the invertebrates and Mr. Lyddeker the vertebrates.

It is well to remark at the outset that the arrangement is not "stratigraphical" as in Lyell's "Elements." That is, it does not follow the geological sequence of the formations. It is entirely zoölogical. While this is far less convenient for the student of a special horizon, it is the only way of treating the subject in a biological manner and avoiding constant repetition. It is, of course, subject to the inconvenience that the fossils of the various systems are mingled in such a way as to destroy the "facies" whereby a system may be readily recognized and is for that reason less suited to a beginner than the other arrangement, just as a geological museum, zoölogically arranged, is almost infinitely puzzling to a young geologist.

Coming now to the body of the work and beginning with the lowest class, the rhizopods, very slight traces of the Foraminifera have been met with below the Carboniferous rocks, but in these they become so abundant that rock-masses are composed of their remains, such as the great Fusulina limestone of Russia. The white chalk of Europe is considered as closely resembling the Globigerina ooze of the Atlantic, the lower proportion of silica in the former being chiefly due to its segregation as flint—a fact bearing on some modern geological problems.

A summary of the arguments anent Eozoon is appended in which the case is very fairly stated, the author considering that the vexed question regarding its nature is still incapable of final solution. He adds the caution drawn doubtless from his own large experience with corals that only the best specimens can fairly be employed as evidence toward the solution of this problem,* and also remarks that until mineralogists or petrologists are able to point in some unquestionable mineral or rock to a structure strictly comparable with the "canal-system" of Eozoon they are not entitled to assert that the latter has a purely inorganic origin.

Remains of radiolarians are also very rare in the older rocks and less abundant than those of the preceding group in Mesozoic deposits. In some of the Tertiary beds, however, they are so abundant that they constitute a great part of the mass. The well known "Barbadoes Earth" is one of them, a friable, chalky marl, rising to a hight of 1,000 feet above tide.

In the chapter on the sponges we find the subject brought well up to date, except perhaps in the regard to Dictyophyton. Receptaculites is well discussed and illustrated by the recent investigations of Dr. Hinde.† Dr. Billings' figure is shown to represent Ischadites rather than Receptaculites.

Sponges are found first in the Cambrian rocks of S. Wales, *Protospongia fenestrata* occurring at St. David's Head, and they are especially abundant in the Carboniferous and Cretaceous formations. "The

* To the writer's knowledge much material has been distributed by dealers and others as Eozoon which contains no eozoic matter at all.

† Fig. 60 should be numbered 61.

nodular flints in the white chalk have been produced by the solution of the skeletons of flinty sponges and the redeposition of the silica in solid form."

But the author is especially at home among the Cœlenterata which have formed the chief object of his studies for many years. Accordingly, we find them treated at considerable but not, considering their importance and difficulty, too great length, in 170 pages. It is manifestly impossible here to follow our author in any detail, but a few points may be noted. He is apparently inclined to regard that most ancient fossil Oldhamia as of vegetable rather than of animal origin, an opinion in which we think few will agree with him. If organic, it is more likely that a frond of a zoöphyte should have been preserved from Lower Cambrian days than a sea-weed. The recent discovery of trilobites in strata of similar age in N. Wales is rather significant in the same direction.

In the jelly-fish here belonging (Lucernarida) we find curious evidence of the possibility that one of these soft-bodied creatures may leave a lasting impression on the rock, so that if not itself a fossil the record of its existence at least survives. From the famous quarries of smooth lithographic limestone at Solenhofen has come a cast considered to represent the swimming-bell of a jelly-fish, and Nathorst, of Sweden, has shown cause for believing that Torell's so-called plant "Eophyton" is only the trail of one of these animals in soft mud.

In the chapter on stromatoporoid corals, the author, in speaking of the anomalous genus "Bentricea," inclines to the view that its nearest relationship is here and that it is allied to Labechea and Idiostroma, but at the same time refrains from any positive statement.

As might be expected the Zoantharia are very fully and excellently treated. The author's familiarty with this branch of his subject is well shown by the wealth of illustration here displayed, much of which is original. In no part of the subjects of the first volume is the progress of the science more clearly shown than here. Any one who recalls the time when Milne Edwards and Lonsdale commenced their labors, will remember what a chaos this part of our museums and treatises exhibited. Corals were the "bête noire" of the collector and of the student. But thanks to the recent laborers in this field, among whom Prof. N. has been by no means the least, and thanks also perhaps in an equal degree to those who have so vastly improved the mechanical processes of cutting, slicing and polishing specimens, the light is beginning to dawn where all was previously darkness, and before long we may hope to be able to refer well preserved fossil corals to their proper zoölogical position with reasonable certainty.

In the difficult group of the monticuliporoids the author confesses the difficulty which he feels regarding their zoölogical affinity—whether they should be regarded as a peculiar group of corals or an equally peculiar group of Polyzoa.

Echinodermata are treated under the two heads of Echinozoa and Pelmatozoa. Of these the latter are by far the more important in

palæontology in consequence of the great numbers and exquisite beauty of the class Crinoidea which it contains. Dr. N. adopted the classification of Wachsmuth and Carpenter, and divided them into the Palæocrinoidea and Neocrinoidea, the former comprising all the known palæozoic crinoids, and nearly corresponding with Müller's Tesselata; the latter including all post-palæozoic crinoid forms and nearly corresponding with Müller's Articulata and Costata.

The distinctive characters of the first group are a calyx large and massive compared with the arms, interradial plates usually present and often united with the radials so as to form part of the calyx; and interradial plates specially developed rendering the calyx unsymmetrical, and also the presence of a plated vault on the ventral surface. In these points they differ from the Neocrinoidea.

But in an appendix the author says that while the work was passing through the press the discovery was made of the ventral coverings of Encrinus and Taxocrinus, "the latter genus having a plated disc exactly like that of a neocrinoid" and thus bridging over the previously existing gap between the two groups.

Owing to the softness of the bodies of the Annelida the palæontologist has usually to deal with merely the tracks which they left on the sands. The reference of one of these, Scolithus, to the Clinton group is probably an error for the Medina. Many of the so-called plant-fossils of the older rocks are attributed by Nathorst to the tracks of annelids. Curious vermiform masses at Solenhofen are probably fossil worm-casts.

On the other hand the author shows that the Myrianites of Europe and North America is not a trail at all but "the edge of some vertical laminar expansion lying at right angles to the strata." In regard to Grossopodia the suggestion is made that it may have been produced by a gasteropod, and the trail of *Purpura lapillus* is given in illustration.

Regarding the well known and disputed conodonts there seems to be some divergence of opinion between the two authors, one of them speaking of these minute fossils as belonging to the invertebrata and the other apparently inclined to favor a higher origin. See pp. 480 and 922.

The Arthropoda occupy rather more than 100 pages, and of these the Crustacea are treated under fifteen orders, a few, as might be expected, monopolizing most of the space. These are the Ostracoda and Phyllopoda, the trilobites and eurypterids. The chapter on the former gives an excellent and very condensed summary of what is at present known* with details in regard to the recent discoveries of the locomotive organs of this remarkable extinct order. Hither the author refers Climactichnites, noting the suggestion that it may have been the track of an eurypterid. No eurypterid is, however, known from the Potsdam rocks where these trails occur. Rusichnites he considers with Dawson the cast of the burrow of a trilobite as it is sometimes connected with a series of markings resembling Asaphoidichnus. A very useful sum-

* We may remark in regard to one point, that the vertical range of Conocoryphe is given as from the upper Cambrian to the Ordovician but the recent discovery of *Conocoryphe viola* in the Penrhyn slates of north Wales carries this genus down to a much earlier date in the Lower Cambrian.

mary of the classification of the order is appended according to Barrande.

The Malacostraca and the eurypterids are dismissed somewhat briefly, the former in ten, and the latter in four, pages.

The Arachnida have of late awakened great interest in consequence of the almost simultaneous discovery of Scorpions in Gothland, Scotland and New York, in Silurian strata, the earliest previously known being of Carboniferous age. Although the evidence of the air-breathing habit in those animals is not so strong as might be desired there can be no doubt of their zoölogical relationship. Possibly they were aquatic. The author says, "It is probable that some of the more ancient forms were littoral in habit." He includes all the three described, Palæophonus, Eoscorpius and Proscorpius.

A few years ago no fossil insect was known except those which attracted attention by being found in amber. But now a large insect fauna has been discovered and by the labors of M. Brongniart and Mr. Scudder the broken fragments have been studied and we already have a fair idea of the line of development of the class. "Between 2,000 and 3,000 species of fossil insects have been described."

The oldest known insect is Palæoblattina douvillei, from the Silurian of France. No more are known till we reach the Upper Devonian of North America. The Carboniferous, both of Europe and America, is rich in insect remains. The Trias of Colorado, the Lias and Wealden of England, Germany, and Switzerland, the Oölite of Solenhofen and the Tertiary on both continents, have all contributed largely to the history of insect-life.

All palæozoic insects are included in the Palæodictyoptera of Scudder, a group of generalized hexapods in which metamorphosis was not complete, the four wings were equally developed and the neuration was simple. The four groups into which this order is divided—the orthopteroids, the neuropteroids, the hemipteroids, and the coleopteroids, foreshadow the four modern orders after which they are named.

At later dates more clearly defined representatives of these orders began to appear—the Hemiptera, in the Jurassic as cicadas, and in the Cretaceous as plant-lice and water-scorpions, the Orthoptera in the Trias as cockroaches, the Neuroptera in the Lias as white ants, etc. Of insects undergoing complete metamorphosis the Diptera, with a few exceptions, appear first in the Tertiary, chiefly in amber, the Lepidoptera in the Jurassic and Cretaceous, and the Hymenoptera in the Middle Tertiary, excepting the *Palæomyrmex* of Heer, if correctly determined, from the Swiss Lias, and a very few other Mesozoic forms. The Curculionidæ, according to Mr. Scudder, are the oldest of the Coleoptera and date from the Triassic. Most of the leading existing families of this order had representatives at about the same epoch.*

*The writer has some specimens of Trigonocarpon from the English Coal-measures, which have apparently been bored by the larva of some insect, probably a weevil. This would indicate a yet greater age for some of the group of the Curculionidæ.

In the summary of the Polyzoa the author has made liberal use of his Canadian and American experience, and his pages exhibit a number of original figures of fossils from the western continent. These, of course, belong to the Cyclostomata or older group, the Cheilostomata being almost exclusively of later date.

The large and important class of Brachiopoda to which belong the oldest known animals on the globe (Eozoon excepted) is well treated, but not at great length. The work of Davidson of course here forms the base. The leading characters of the 15 familes into which the class is divided are fully and clearly given.

The chapter on the Lamellibranchiata contains a good sketch of the leading points in their structure in so far as it relates to palæontology and a summary of the orders and families. It is, however, so condensed that it is impossible to give any brief account of it. The nature of the subject also, this group having been a favorite topic with palæontologists for many years, precludes the introduction of much new matter in a work like the present.

In the treatment of the Gasteropoda we note that the three air-breathing families represented by the genera Cyclostoma, Acicula and Helicina are included in the prosobranchiates in spite of their possessing a pulmonary chamber; other structural features being considered of greater importance. The latest classification of the group according to the structure of the "radula" or tongue is not applicable, as the author shows, to fossil forms, which are most readily arranged as holostomatous and siphonostomatous—the forms with entire mouth being the more ancient and the less specialized. Of the palæozoic gasteropods the families Capulidæ, Pleurotomariidæ, Bellerophontidæ (type extinct) and Euomphalidæ are by far the most important. Most of the families (52 in all) belong to mesozoic and cænozoic time.

The Opisthobranchiata and Heteropoda being nearly destitute of hard parts have few fossil representatives.

Among the pteropods the author includes, and we think wisely, the disputed forms Conularia, Hyolithes and Tentaculites. Indeed it would be difficult to indicate any other more probable place for them. This reference makes the pteropods nearly or quite coeval with the oldest known fossils, Eozoon excepted, since Hyolithes descends even lower than the lowest limit here assigned (Upper Cambrian), *H. danianus* and *H. gracilis* having been described by Mathew from the St. John group of Nova Scotia. The extinct Conularia was the largest of all known pteropods, some species attaining the length of a foot. In the case of Tentaculites Prof. N. thinks it probable that some of the forms referred to this genus belong rather to Cornulites and quotes Hall who has pointed out that all the forms from the Ordovician rocks of N. America are curved and longitudinally striated. But if all these belong to Cornulites it is almost certain that some case showing marks of attachment would have been found.

The pulmonary gasteropods are at present of slight palæontological importance. The earliest forms are *Zonites priscus* and *Pupa vetusta*

of Dawson from the Carboniferous of Nova Scotia, and save a few intermediate fossils we must wait till the Tertiary age for the frequent appearance of the now abundant land and fresh-water snails.

On the other hand the cephalopods are the most important, attractive and interesting of all the fossil molluscan fauna. Not however so much in their higher types as in their lower forms, for excepting the Belemnites of the Lias, Oölite and Chalk, the dibranchs now so abundant require small space in a manual of palæontology. Of the genus Belemnites alone three or four hundred species are already known. A few forerunners of the coming host come up from the Trias and equally few descendents linger on into the Miocene but as a whole the group is specially characteristic of Liassic, Oölitic and Cretaceous strata.

But the tetrabranchs are among the most wonderful and beautiful of fossils. In the palæozoic rocks the nautiloid type prevailed with simple sutures and siphuncle variable in position and often contracted. Regarding this group Prof. N. says:

"The earliest types of the Nautiloidea appear in the Upper Cambrian deposits where the genera Orthoceras and Cyrtoceras are represented. In the Ordovician rocks an enormous number are known, no fewer than 463 species having been recorded by Barrande from rocks of this age in Bohemia alone." "The maximum development of the group takes place, however, in the Silurian age, the Bohemian area having yielded to the researches of Barrande over 1,000 species. In the later palæozoic rocks the nauliloids exhibit a progressive diminution in numbers and only Nautilus and Orthoceras survive the close of this period, the latter finally dying out in the Trias. The few known Tertiary types belong to Nautilus or closely allied forms, and the sole existing representatives of the sub-order are four living specie of Nautilus."

Two genera only of this great family have the septal necks directed forward—Bathmoceras and Nothoceras. In all others they are as in the modern Nautilus.

But it is after passing into the Mesozoic age that the full glory of the tetrabranchiates appears. The long straight shell so frequent among the nautiloids has given place to an elegant spiral, and the simple septa have been replaced by others with plaits and folds so complicated and beautiful that their outline gives a dendritic appearance to the casts of the shell.

In late mesozoic times the cephalopod shell shows a tendency again to uncoil and the perfect spiral of the ammonite is succeeded by the imperfect or partial coil of the hamite, scaphite and even the straight baculite. But in regard to these genera we cannot do better than quote the words of our author—

"Formerly all these forms were grouped under a comparatively small number of the genera such as Ceratites, Ammonites, Hamites, Turrilites, Baculites, etc., distinguished mostly by the mode of growth and the resulting form of the shell. By far the most important of these groups was the comprehensive genus *Ammonites* embracing the great series of forms commonly known as "Ammonites." Through the re-

searches of Hyatt, Neumayr, Mojsisovics, Waagen, von Zittel and others it has now been shown that the old genus *Ammonites* can no longer be retained but that the types formerly included under this name admit of a natural division into a number of genera which in turn constitute a number of distinct families. These modern divisions are distinguished by such characters as the size of the body chamber, the form of the sutures, the shape of the aperture and the presence or absence of an Aptychas."

In accordance with this principle the names *Phylloceras*, *Haploceras*, etc., have been introduced in place of the old term *Ammonites*. If it had been possible to use a uniform termination the transition would have been attended with little difficulty, but this was not done. It is consequently usual, and, indeed, almost necessary, to give in addition the old name to prevent needless trouble. Thus we read *Hoplites* (*Ammonites*) *falcatus*.

"The earliest representatives of this vast group of the ammonoids appear in the Trias. In the Mesozoic it undergoes a vast development. In the Cretaceous rocks new and varied types are found but at its close the entire group of the Ammonites underwent an apparently sudden and almost complete extinction."

Regarding the bodies called "Aptychus" the author gives no opinion merely quoting the two views, viz., that they were protective plates developed within the walls of the nidamental gland in which case all such ammonites must be females, and that they are produced by the calcification of the hood and served as the operculum to those species that possessed them. In the former case they were nearly homologous to the "shell" of this argonaut.

The author has been very careful in regard to the terminology—a stumbling-block to many palæontologists—sometimes in consequence of their want of classical knowledge, and occasionally, we fear, in consequence of indifference to the details of the work. For this the accurate worker will feel much indebted to him. Incorrect formation of terms is a great annoyance to those who realize it, especially when with the incorrectness comes, as is often the case, an uncouth and unmelodious sound.

At a later date we will follow Mr. Lyddeker through the second volume of this valuable manual.

Geological and Palæontological Relations of the Coal and Plant-bearing Beds of Palæozoic and Mesozoic Age in Eastern Australia and Tasmania; with special reference to the Fossil Flora. Described, illustrated, and compared with Analogous Deposits in other Countries. By OTTOKAR FEISTMANTEL, M. D., *etc., Sydney, New South Wales, 1890.* This is No. 3 of the Palæontological series of memoirs published by the Geological Survey of New South Wales. The coal and plant-bearing beds of eastern Australia and Tasmania are typically represented in New South Wales and include *Silurian beds* with a plant, *Spirophyton*, etc.; the *Goonoo Goonoo beds* with *Lepidodendron nothum* etc.,

referred to the Devonian; *Lepidodendron beds*, rich in fossil plants, belonging to the Lower Carboniferous: *Marine beds* with intercalated coal measures of the age of the middle and upper Carboniferous; *Newcastle beds*, with coal, and regarded as Permian; and the *Hawkesbury-Wianamatta* beds, with coal and numerous fossil plants, referred to the lower Mesozoic. Corresponding series of strata occur in Victoria, Queensland and Tasmania.

A conglomerate occurring in the *Marine beds* of the Upper Carboniferous contains erratic blocks together with striated boulders and pebbles, and the Australian geologists conclude that it has been formed largely through the agency of drifting ice. It would thus seem that the southern hemisphere at least had been subjected to the rigors of a glacial epoch near the close of the Palæozoic. During this period of low temperature we have the beginning of a Mesozoic flora which, associated with a Carboniferous fauna, persists in increasing numbers of genera and species throughout the time represented by the *Newcastle*, or *Permian* strata. Dr. Feistmantel correlates the Carboniferous conglomerate of New South Wales with the Bacchus Marsh beds of Victoria, the Talchir group of India, and probably with the Karoo formation of Africa, all of which groups seem to belong to the horizon of the upper Carboniferous and all, according to competent authorities, appear to have been formed in part at least by the action of floating ice. The volume contains 183 pages, 70 pages being devoted to bibliography, and correlation of strata, and the remainder to description of species. A few species of fishes and amphibia are noted, but the work is chiefly devoted to the description of fossil plants. Thirty plates illustrate the species described.

Records of the Geological Survey of New South Wales. Vol. I, Part III, 1889. This part of of Vol. I embraces pages 149–183 and Plates XXV–XXX. The table of contents will give an idea of the scope of the publication. The articles, numbered XVI to XIX, inclusive, are:

On the occurrence of the Genus *Meiolania* in the Pliocene Deep Lead at Canadian, near Gulong; With Plates XXV and XXVI; by R. ETHERIDGE, Jr., Palæontologist.

The Leucite-Basalts of New South Wales, with Plates XXVII and XXVIII; by T. W. EDGEWORTH DAVID and WILLIAM ANDERSON, Geological Surveyors.

On our present knowledge of the Palæontology of New Guinea, with Plate XXIX; by R. ETHERIDGE, Jr., Palæontologist.

On the Mineral Spring at Rock Flat creek, near Cooma, Monara District, with Plate XXX; by WILLIAM ANDERSON, Geological Surveyor.

Mr. Etheridge introduces his first paper by saying, "So far as I am aware, neither the remains of the large extinct Lacertilian *Megalania* (? *Varanus*) *prisca*, Owen, or either species of the horned Chelonian *Meiolania* have so far been found in any of the New South Wales Pliocene or Post-Tertiary deposits. Both genera were met with in accumulations of the latter age in Queensland, and the last named at Lord Howe Island."

The Fossil Fishes of the Hawkesbury Series at Gosford. By ARTHUR SMITH WOODWARD, F. Z. S., F. G. S. Sydney, 1890. This volume of 57 pages and 10 plates is No. 4 of the palæontological series of memoirs of the Geological Survey of New South Wales. It is devoted to the description and illustration of an interesting series of fossil fishes, which, taken with the previously described forms from the same horizon, confirm the views respecting the Triassic age of the Hawkesbury-Wianamatta series of New South Wales.

Western Australian Fossils. 1. Stromatoporoidea. By PROF. H. A. NICHOLSON, M. D., F. G. S. 2. Corals and Polyzoa. By GEORGE JENNINGS HINDE, Ph. D., F. G. S. (Extracted from the Geological Magazine, Decade III, Vol. VII. May, 1890,)

The stromatoporoids noted by Dr. Nicholson in this paper are *Actinostroma clathratum and Stromatoporella eifelensis*, species originally described by Nicholson from the middle Devonian of Germany, and now found to occur at the same horizon on the opposite side of the globe in western Australia. The corals and polyzoa by Dr Hinde embrace Devonian and Carboniferous forms. Seven of the species are new, and a new generic name, *Plerophyllum*, is proposed to take the place, probably of Dr. Koninck's *Pentaphyllum*, a name first employed in 1821 to designate a genus of Coleoptera.

Remarks on some Fossil Remains considered as peculiar kinds of Marine Plants. BY LEO LESQUEREUX. (From the Proceedings of the United States National Museum, vol. xiii, 1890, No. 792, pp. 5–12, pl. i). We are told by the editor that "this paper was prepared and submitted for publication some months before the death of the author," and it is professor Lesquereux's last contribution to paleobotany. Certain peculiar organisms are described, which were collected by the Rev. H. Herzer in the Devonian rocks of Ohio. The *Halymenites herzeri* is from the Upper Helderberg limestone at Sandusky, while *Cylindrites striatus* and *Physophycus bilobatus* are from the Erie shale (Portage) bordering lake Erie, near Cleveland. The Cylindrites occur in arenaceous shales while the Physophycus are found in flattened concretions distributed in the shale. The stem of Halymenites is split lengthwise and shows its inner structure, which is hollow and bordered with cellular matter that is intermixed with a large number of round spores, or reproductive gemmules. "The specimen is remarkable and of great value, for until now very few fossil remains of marine plants have been discovered with their internal texture in such a state of preservation that its characters were possibly discernable." The author states that the specimens of Physophycus "belong to that class of ill-defined fossil remains fitly called problematic organisms by Saporta. By some they are regarded as the remains of marine plants of old types that have been gradually effaced and are now extinct.... others, refusing to find in them any trace of vegetable nature,......regard them as the result of mere mechanical mouldings produced by the movement of water or the tracks or burrows of different kinds of animals upon soft muddy surfaces."

Stolicfkaria and Syringosphæridæ: PROF. P. M. DUNCAN in the Records of the Geological Survey of India, vol. xxiii, part 2, p. 80, brings forward undeniable proofs that his genus *Stolicfkaria* is quite distinct from *Heterastridium* A. E. von Reuss. According to Prof. Duncan, Dr. Nicholson has figured a section of what the latter considers to illustrate the minute structure of *Stolicfkaria* Dunc., which Prof. Duncan says is not a section of his genus but of *Syringosphæridæ* and Dr. Nicholson again falls into error by figuring *Stolicfkaria granulata* Dunc. which is clearly *Syringosphæria porosa* Dunc. The paper then continues by describing two new species and two new varieties of *Syringosphæridæ*, *S. medlicotti*, *S. intermedia* sp. nov. *S. plana* and *S. monticulariæ*, var.

The Geographical Distribution of Fossil Plants. By LESTER F. WARD. Pages 663–960, with map. (Accompanying the eighth annual report of the director of the U. S. Geological Survey.) This is a well arranged and practically complete review and bibliography of the literature of paleobotany. The published investigations which have been made in all countries are noticed in geographic and chronologic order, with identification of the geologic horizons as far as practicable, 114 pages being devoted to the countries and provinces of Europe, 13 pages to those of Asia, 18 pages to Africa, the Sunda islands, and Australasia, and the remainder to the Arctic regions and North and South America. Forty-five states and territories of the United States, including the District of Columbia, the Yellowstone National Park, and Alaska, have fossil plants, the richest being Pennsylvania with its great representation of the coal flora. The accompanying map shows the localities of fossil plants in this country, colored to distinguish their geologic age. A good index, including more than 7,000 references, makes this work a most convenient and valuable manual.

The Paleozoic Fishes of North America. By JOHN STRONG NEWBERRY. pp. 340; plates 53. (Monographs of the U. S. Geol. Survey, vol. xvi, 1889). After referring to Prof. E. W. Claypole's discovery of Pteraspidian fishes in the Upper Silurian rocks of Pennsylvania, the earliest fossil fishes thus far known, Dr. Newberry describes, in about 50 pages, the distribution and the generic and specific characters of the fishes of our Devonian system, which, as he states, is perhaps better represented in eastern North America than anywhere else. The next 150 pages similarly treat the fishes of our Carboniferous rocks, in which both their numbers and variety far surpass the preceding period. No Permian fishes from this country have come under the author's observation; and the remainder of the volume consists of the plates, with their explanations, and the index. In a previous monograph (xiv of this series) Dr. Newberry has described our Triassic fishes, gathering in these two volumes the results of many local surveys. Prominent among these in its wealth of Paleozoic ichthyology is the geological survey of Ohio, for which Dr. Newberry, in his reports on the paleontology of that state, has discussed the classification of our older fossil fishes and their relations to living forms.

Fossil Wood and Lignite of the Potomac Formation. By FRANK HALL KNOWLTON. pp. 72; plates 7. (Bulletin of the U. S. Geol. Survey, No. 56, 1889). The first part of this report gives a concise history of the progress of study of the internal structure of fossil wood and lignite, with the bibliography of this subject. Lignite and silicified wood occur in the Potomac formation on the Potomac and James rivers, and in Baltimore. One of the trunks of silicified wood, exposed by the excavation for the new reservoir in Washington, was between 30 and 40 feet long, with a diameter of nearly 2 feet. Generally the tissue of the silicified specimens is very perfectly preserved, and five species are described, all of them new, four being referred to the genus Cupressinoxylon, and one to Araucarioxylon. A summary of Mr. Knowlton's investigation has been presented in the GEOLOGIST, February, 1889.

CORRESPONDENCE.

THE GLACIATION OF THE CORDILLERA AND THE LAURENTIDE. In the excellent paper on the *Glaciation of the Northern Part of the Cordillera* read by Dr. G. M. Dawson before the Royal Society of Canada at the meeting held in May last, an abstract of which appeared in the September number of the AMERICAN GEOLOGIST, the author proposes the appellation *Laurentide glacier* for the ice-sheet which, in the Pleistocene period, occupied the mountains of that name, to distinguish it from "its western fellow," which he had designated the Cordilleran glacier. Further detailed study of the phenomena of these important glacial centres is however, evidently required, and would, I believe, result in showing that the ice masses referred to may not have been altogether so continuous and massive as Dr. Dawson assumes. It is not improbable that there, as elsewhere, the ice-sheets may have consisted of a number of local glaciers, large and small, dependent upon the atmospheric conditions, precipitation, temperature, etc., of the respective regions, which, unless these were wholly different from what now obtain in the interior of the continent, would not be favorable to the production of large glaciers. Instead, therefore, of designating these ice-sheets simply as the Laurentide glacier and the Cordilleran glacier, I would suggest the names *Laurentide glacier system*, *Cordilleran glacier system*, or, as I prefer them, *the Laurentide system of glaciers*, *the Cordilleran system*, *etc.*

In the Appalachian mountain range it has been shown by Dr. Ells of the Geol. Survey, Can., and the writer (Annual Reports, Geol. Surv. Can., vol. ii. parts J and M, vol. iii. part K) that glaciers moved northwestwardly on the St. Lawrence slope, while Hitchcock, Dana and others have long ago proved that they flowed south-eastwardly on the southern

or New England side of the main axis. This region has therefore been occupied with ice which formed separate and independent sheets in the Pleistocene period, and I would prefer for them the designation of the *Appalachian system of glaciers.* These seem, so far as observations extend, to have been largest on the New England slope, and formed there, in some areas at least, massive, confluent ice-sheets, which, in their movements were comparatively independent of minor surface features. Reasoning from the analogy between existing glaciers in different parts of the world, and those of the Post-Tertiary age, it seems now a pretty safe inference as regards the latter, that the largest ice-masses must have accumulated at or near the borders of continents, where the conditions of moisture, temperature, etc., as well as the topographic features, were most favorable for their development. It is just possible too that the glaciers of the eastern and western parts of North America may not have been strictly contemporaneous, *i. e.*, may not have reached their maximum thickness and extent at the same time, as suggested by Mr. Israel C. Russel in his valuable paper entitled *Notes on the Surface Geology of Alaska* (Bulletin Geol. Soc. of America, vol. i., pp. 99–182).

Belledune, New Brunswick, Can., ROBERT CHALMERS.
Sept. 8th, 1890. Geol. Surv. of Can.

PERSONAL AND SCIENTIFIC NEWS.

PROF. F. P. VENABLE enumerates twenty-three meteorites with brief descriptions, which have been reported as found in North Carolina. Of these nearly all have passed out of the state, not even fragments being preserved there. Considering that for the entire world there have been recorded, according to Huntington's catalogue of 1887, only 424 meteorites that have reached the earth, North Carolina may be considered to have been well reported. The list is valuable, and evinces much labor and patient research. It is published in the Journal of the Elisha Mitchell Society, vol. vii., pp. 33–52, 1890.

MR. I. C. RUSSELL, OF THE UNITED STATES GEOLOGICAL SURVEY, lately returned from Alaska where he made a careful examination of the phenomena of existing glaciers, having been absent since the opening of the season of 1890. According to Mr. Russel there is a large amount of ice-covered country, more than has been supposed, much of the tundra region being underlain by ice at the depth of a few feet or inches. There are also many moving glaciers. The tundra ice which underlies thousands of square

miles bears no trees, only moss and small shrubs; but in the region of glaciers the surrounding country is apt to be forested.

THE OCCURRENCE OF GONIOPHYLLUM PYRAMIDALE HISINGER, IN AMERICA.—The fact that *Goniophyllum pyramidale* Hisinger occurs in America seems to have escaped general notice, although its existence here has been known to some geologists for a number of years. So far as I know, the first individuals of this species found in this country were discovered by professor W. H. Norton, of Cornell College, Iowa. They were taken from strata of the Niagara period, near La Motte, Dubuque Co., Iowa. Since the first discovery individuals of the same species have been found near Monticello, Maquoketa, and a few other places in the same state. The first specimens were submitted to Dr. Rominger for identification, and casts were distributed by Prof. Norton to a number of geologists, but it would seem that the fact that this peculiar and very interesting genus and species occurs on this side of the Atlantic has not yet found a place in geological literature. Is this species known to occur in America outside of Iowa? It would be interesting to know its geographical range.

THE WESTERN SOCIETY OF NATURALISTS will hold its annual meeting in the buildings of Purdue University, at LaFayette, Indiana, Wednesday and Thursday, November 12th and 13th, 1890. The President of the society, Chancellor C. E. Bessey, will deliver his address on Wednesday evening.

The Executive Committee propose that this meeting discuss (1) the question of what science and how much should be required for entrance to college classes. Several educators have been requested to come prepared to open the discussion and have responded favorably. (2) The relations of investigation to instruction. (3) New processes in technique, new methods in museum administration, new pieces of appartus, etc. The question of the publication of proceedings and of altering the scope of the Society so as to admit of the presentation of papers embodying the results of original research, will be brought up.

IN THE BULLETIN OF THE MUSEUM OF COMPARATIVE ZOOLOGY, at Harvard College, Vol. xx, No. 2, Prof. Alexander Agassiz communicates a note on the *Rate of Growth of Corals*, which has an interest to geologists. Corals were found attached to the cable laid between Havana and Key West. The cable was repaired and relaid in the summer of 1881, and in June, 1888, the specimens that form the subject of the note were taken from the cable in Key West harbor. They therefore represent the growth of about seven years. *Orbicella annularis* had attained a thickness of two and a half inches, *Manicina areolata* had made a growth of about one inch above the cable, while *Isophyllia dipsacea* equalled the *Orbicella* in rate of growth.

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ON THE CAUSE OF THE GLACIAL PERIOD.

By WARREN UPHAM, Somerville, Mass.

The fascinating astronomic theory that the Glacial period was due to meteorologic conditions brought about by a stage of maximum eccentricity of the earth's orbit, extending from 240,000 to 80,000 years ago, which Croll and James Geikie have so ably advocated, is doubted from the meteorologist's standpoint by Woeikof, and seems wholly untenable in view of the geologic evidences that not many thousands of years have passed since the departure of the ice-sheets.

In various localities we are able to measure the present rate of erosion of gorges below water-falls, and the length of the postglacial gorge divided by the rate of recession of the falls gives approximately the time since the Ice Age. Such measurements of the gorge and falls of Saint Anthony by Prof. N. H. Winchell show the length of the postglacial or recent epoch to have been about 8,000 years; [1] and from the surveys of Niagara falls, Mr. G. K. Gilbert believes it to have been 7,000 years, more or less.[2] From the rates of wave-cutting along the sides of lake Michigan and the consequent accumulation of sand around the south end of the lake, Dr. E. Andrews estimates that the land there became uncovered from its ice-sheet not more than 7,500

[1] Geology of Minnesota, Fifth annual report, for 1876; and Final report, vol. ii, pp. 313–341. Quart. Jour. Geol. Soc., vol. xxxiv, 1878, pp. 886–901.

[2] Proceedings, A. A. A. S., vol. xxxv, for 1886, p. 222. "The History of the Niagara River." Sixth An. Rep. of Commissioners of the State Reservation at Niagara, for 1889, pp. 61–84.

years ago.[3] Professor Wright obtains a similar result from the rate of filling of kettle-holes among the gravel knolls and ridges called kames and osars, and likewise from the erosion of valleys by streams tributary to lake Erie;[4] and Prof. B. K. Emerson, from the rate of deposition of modified drift in the Connecticut valley at Northampton, Mass., thinks that the time since the Glacial period cannot exceed 10,000 years.[5] An equally small estimate is also indicated by the studies of Gilbert[6] and Russell[7] for the time since the last great rise of lakes Bonneville and Lahontan, believed to have been contemporaneous with the last great extension of ice-sheets upon the northern part of our continent.

Prof. James Geikie maintains that the use of palæolithic implements had ceased, and that early man in Europe made neolithic (polished) implements, before the recession of the ice-sheet from Scotland, Denmark, and the Scandinavian peninsula;[8] and Prestwich suggests that the dawn of civilization in Egypt, China, and India, may have been coeval with the glaciation of northwestern Europe.[9] In Wales and Yorkshire the amount of denudation of limestone rocks on which boulders lie has been regarded by M. D. Mackintosh as proof that a period of not more than 6,000 years has elapsed since the boulders were left in their positions.[10] The vertical extent of this denudation, averaging about six inches, is nearly the same with that observed in the southwest part of the Province of Quebec by Sir William Logan and Dr. Robert Bell where veins of quartz marked with glacial striæ stand out to various hights not exceeding one foot above the weathered surface of the enclosing limestone.[11]

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[3] Transactions of the Chicago Academy of Sciences, vol. ii. Southall's Epoch of the Mammoth and the Apparition of Man upon the Earth. 1878, chapters xxii and xxiii.

[4] Am. Jour. Sci., III, vol. xxi. pp. 120–123, Feb., 1881; The Ice Age in North America, chapter xx, p. 466.

[5] Am. Jour. Sci., III, vol. xxxiv, pp. 404, 5, Nov., 1887.

[6] U. S. Geol. Survey, Second annual report, p. 188.

[7] U. S. Geol. Survey, Monograph xi, Geological History of Lake Lahontan, p. 273.

[8] Prehistoric Europe, p. 360; Address to the Geological section of the British Association, 1889.

[9] Prestwich's Geology, vol. ii, 1888, pp. 534, 5; Quart. Jour. Geol. Soc., vol. xliii, pp. 407, 8.

[10] Quart. Jour. Geol. Soc., vol. xxxix, 1883, in Proceedings, pp. 67–69. Compare id., vol. xlii, 1886, pp. 527–539.

[11] Bulletin of the Geological Society of America, vol. i, 1889, p. 306.

Another indication that the final melting of the ice-sheet upon British America was separated by only a very short interval, geologically speaking, from the present time, is seen in the wonderfully perfect preservation of the glacial striation and polishing on the surfaces of the more enduring rocks. Of their character in one noteworthy district, Dr. Bell writes as follows:—"On Portland promontory on the east coast of Hudson's bay, in latitude 58°, and southward the high rocky hills are completely glaciated and bare. The striæ are as fresh-looking as if the ice had left them only yesterday. When the sun bursts upon these hills after they have been wet by the rain they glitter and shine like the tinned roofs of the city of Montreal."[12]

Forbidden by the shortness of the postglacial epoch from attributing the Ice Age to the astronomic condition of maximum eccentricity, we must look for other causes of this extraordinary geologic period; and these seem to be found in great uplifts of the glaciated areas, of which for this continent Prof. J. W. Spencer has given an impressive review in the recently published first volume of the Bulletin of the Geological Society of America. Though he has not proceeded to interpret these observations as revealing in continental elevation the probable cause of the colder climate and accumulation of ice-sheets during the Glacial period, I believe that this is a legitimate conclusion, and that it strongly reinforces the arguments long ago advanced by Lyell and Dana and recently emphasized anew by Wallace. The submarine border of the continental plateau to depths of more than 3,000 feet is cut by valleys or channels, which if raised above the sea level would be fiords or cañons. These can be no other than river-courses eroded while the land stood much higher than now; and its subsidence evidently took place in a late geologic period, else the channels would have become filled with sediments.

According to the United States Coast Survey charts, as noted by Spencer, the bottom of a submerged valley just outside the delta of the Mississippi is found by soundings at the depth of 3,000 feet. This valley is a few miles wide and is bounded by a plain of the sea bed from 900 to 1,200 feet above its floor. It thus appears that the country north of the Gulf of Mexico has been raised for a short time to a hight of not less than 3,000 feet; and it is important to note in passing that an equal uplift would

[12] Bulletin, G. S. A., vol. i, p. 308.

wholly close the Strait of Florida, 2,064 to 3,000 feet deep, through which the Gulf Stream now pours into the North Atlantic.

The continuation of the Hudson river valley has been traced by detailed hydrographic surveys to the edge of the steep continental slope at a distance of about 105 miles from Sandy Hook. Its outermost twenty-five miles are a submarine fiord three miles wide and from 900 to 2,250 feet in vertical depth measured from the crests of its banks, which with the adjoining flat area decline from 300 to 600 feet below the present sea level. The deepest sounding in this fiord is 2,844 feet.[13]

An unfinished survey by soundings off the mouth of Delaware bay finds a similar valley submerged nearly 1,200 feet, but not yet traced to the margin of the continental plateau.

Again, the United States Coast Survey and British Admiralty charts, as Spencer states, record submerged fiord outlets from the Gulf of Maine, the Gulf of Saint Lawrence, and Hudson bay, respectively 2,664 feet, 3,666 feet, and 2,040 feet below sea level. The bed of the old Laurentian river from the outer boundary of the Fishing Banks to the mouth of the Saguenay, a distance of more than 800 miles, shown by Prof. Spencer's map,' is reached by soundings 1,878 to 1,104 feet in depth. Advancing inland, the sublime Saguenay fiord along an extent of about fifty miles ranges from 300 to 840 feet in depth below the sea level, while in some places its bordering cliffs, one to one and a half miles apart, rise abruptly 1,500 feet above the water.[14]

Greenland is divided from the contiguous North American continent and archipelago by a great valley of erosion, which is estimated from soundings and tidal records to have a mean depth of 2,510 feet below sea level for 680 miles through Davis strait; 2,095 feet for 770 miles next northward through Baffin bay; and 1,663 feet for the next 55 miles north through Smith strait.[15]

On the Pacific coast of the United States Prof. Joseph Le Conte has shown that the islands south of Santa Barbara and Los Angeles, now separated from the mainland and from each other

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[13] Report of U. S. Coast and Geodetic Survey, for 1884, pp. 435–8; Am. Jour. Sci., III, vol. xxix, pp. 475–480, June, 1885; Bulletin, G. S. A., vol. i. pp. 563–7.

[14] J. W. Dawson, "Notes on the Post-Pliocene Geology of Canada," 1872, p. 41.

[15] Smithsonian Contributions to Knowledge, vol. xv, pp. 163, 164.

by channels twenty to thirty miles wide and 600 to 1,000 feet deep, were still a part of the mainland during the late Pliocene and early Quaternary periods.[16]

In northern California Prof. George Davidson, of the U. S. Coast Survey, as cited by Spencer, reports three submarine valleys about twenty-five, twelve, and six miles south of Cape Mendocino, sinking respectively to 2,400, 3,120, and 2,700 feet below the sea level, where they cross the 100 fathom line of the marginal plateau. If the land here were to rise 1,000 feet, these valleys would be fiords with sides towering high above the water, but still descending beneath it to profound depths.[17]

Farther to the north, Puget sound and the series of sheltered channels and sounds through which the steamboat passage is made to Glacier bay, Alaska, are submerged valleys of erosion, now filled by the sea but separated from the open ocean by thousands of islands, the continuation of the Coast Range of mountains. From the depths of the channels and fiords Dr. G. M. Dawson concludes that this area had a preglacial elevation at least about 900 feet above the present sea level, during part or the whole of the Pliocene period.[18]

The general absence of Pliocene formations along both the Atlantic and Pacific coasts of North America indicates, as pointed out by Prof. C. H. Hitchcock, that during this long period all of the continent north of the Gulf of Mexico held a greater altitude, which from the evidence of these submarine valleys is known to have culminated in an elevation at least 3,000 feet higher than that of the present time. Such plateau-like uplift of the continent appears to have exerted so great influence on its meteorologic conditions, bringing a cooler climate throughout the year, that it finally became enveloped by ice-sheets to the southern limit of the glacial striæ, till, and moraines, stretching from Nantucket and Cape Cod to New York city, Cincinnati, Saint Louis, Bismarck, and thence westward to the Pacific somewhat south of Vancouver island and Puget Sound. The thickness of the ice in the region of the White mountains and the Adirondacks was about one mile; and Dana has shown, from the directions of striation and transportation of the drift, that its central portion over the Laurentian

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[16] Bulletin of the California Academy of Sciences, vol. ii, 1887, pp. 515–520.

[17] Ibid., vol. ii. pp. 256–8.

[18] Canadian Naturalist, new series, vol. viii, pp. 241–248, April, 1877.

highlands between Montreal and Hudson bay had probably a thickness of fully two miles. In British Columbia, according to Dr. G. M. Dawson's observations, it covered mountain summits 5,000 to 7,200 feet above the sea.[19]

While thus heavily ice-laden, nearly the whole glaciated area sank below its present level, but for the most part only to a slight amount in comparison with its previous elevation. Beginning at or near a line drawn northeastward through New York city, Boston, and Nova Scotia, the extent of the submergence of the land by the sea, at the time of the recession of the ice-sheet, as shown by fossiliferous marine deposits overlying the till, increases from 150 and 225 or 230 feet on the coast of New Hampshire and Maine to 520 feet at Montreal; 300 to 500 feet on the country southwest of James bay; and about 1,500 feet, according to Dr. Robert Bell, at Nachoak on the eastern coast of Labrador. In British Columbia, including Vancouver island and the Queen Charlotte islands, Dr. Dawson finds evidence of submergence to the amount of 200 or 300 feet while the glacial conditions still endured. During postglacial time the Atlantic and Pacific coasts have been again uplifted, attaining generally a somewhat greater hight than now, the latest movements being mostly subsidence. But in the basin of Hudson bay, as shown by Dr. Bell, the uplift from the glacial depression is still in progress.[20]

Northwestern Europe, also, had a much greater altitude during the later part of the Tertiary era, in which Scandinavia and the British Isles suffered vast denudation, with erosion of fiords and channels that are now submerged 500 to 800 feet beneath the sea.[21] Probably many of these submarine channels are now more or less filled with the glacial drift, so that valleys originally descending continuously toward the margin of the continental plateau have become in some portions changed to enclosed basins. The maximum preglacial elevation probably exceeded the depth of the Skager Rack between Denmark and Norway, which is 2,580

[19] Geological Magazine, III, vol. vi, 1889, pp. 350–2.

[20] For a more detailed review of these postglacial oscillations, and of Quaternary movements of uplift and subsidence in other parts of the world, both in glaciated and unglaciated regions, see Wright's Ice Age in North America, 1889, Appendix by Warren Upham, pp. 573–595.

[21] James Geikie, Quart. Jour. Geol. Soc., vol. xxxiv, 1878, plate xxxiii; The Great Ice Age, sec. ed., pp. 279–284, plates ix–xii.

feet, with a deep submerged valley running from it west and north to the abyssal Arctic ocean.[22]

Under the weight of its ice-sheet, the glaciated area of Europe, like that of North America, sank mostly to a somewhat lower level than it now has, the maximum depression being on the coast of Norway, about 580 feet.[23] From this depression Scandinavia has gradually risen, with pauses during which beaches were formed; and the uplift of that country, as of the region about Hudson bay, continues to the present day.[24]

This subject may be advantageously examined from another point of view, by inquiring what we may learn of the oscillations of the land and its climatic changes during the Quaternary era from the enforced migrations of the flora and fauna of northern countries. The influence of the Glacial period on the distribution of plants and animals has been fruitfully investigated by Edward Forbes, Asa Gray, Alfred Russel Wallace and others, who have thus explained many peculiarities in the geographic range of species, as the occurrence of Arctic plants on the summits of mountains in temperate latitudes, and the identity of a considerable number of species found in the floras of both the United States and Japan, but absent from Europe. As geologists are lately finding valuable additions to our knowledge of important orographic movements of our continent during the Mesozoic, Tertiary and Quaternary eras, from the present conditions of its rivers and their relation to geologic formations, so the pages of the geologic record receive a useful side-light from the range of living species. Professor Gray well stated this bearing of botanic science upon geology, in the conclusion reached by his comparison of the floras of Japan and North America, "that the extant vegetable kingdom has a long and eventful history, and that the explanation of apparent anomalies in the geographical distribution of species may be found in the various and prolonged climatic or other physical vicissitudes to which they have been subject in earlier times."[25]

The general likeness of the Arctic flora all around the globe, the many instances of relationship and identity in the north tem-

[22] Nature, vol. xxiii, p. 393, with map of submarine contour.

[23] Geol. Mag., III, vol. vi, 1889, pp. 157, 8. Nature, vol. xxxii, p. 555.

[24] Nature, l. c.; and vol. xxxix, pp. 488–492.

[25] Memoirs, American Academy of Arts and Science, new series, vol. vi, 1859, pp. 377–452. Am. Jour. Sci., II, vol. xxviii, pp. 187–200. Gray's Scientific Papers, 1889, vol. ii, pp. 125–141.

perate floras, and the increasing divergence of prevailing types as we pass to the equatorial regions and the southern hemisphere, indicate that in late geologic time the northern circumpolar lands have been united, permitting free land communication, and causing the same plants and animals to extend throughout the whole Arctic area. But glacial drift and striæ show that after this a colder climate enveloped northwestern Europe, British America, and the northern part of the United States with thick accumulations of snow and ice; and I believe that this climatic change was due to the increase of the northern elevation of the land, through which the continents had become united. Not only vegetation but all seeds upon the glaciated areas must have been destroyed, though the species were mostly preserved by migration southward. Thus various species of the preglacial circumpolar flora whose retreat from the European ice-sheet and severe cold was cut off by the Pyrenees, Alps, Carpathians, and Caucasus, so that they perished, escaped from extinction in Asia where no general ice-sheet existed, and in North America where no transverse ranges of mountains barred their retreat from the ice. The Glacial period is past, but the mild Arctic climate of Tertiary times has not returned; and species whose range was formerly continuous through the high northern latitudes are now found occupying widely separated temperate districts in Asia and on our own continent, the time since the Ice Age having been too brief for them to become changed into new forms by the influences of their different environment. Many plants, however, have been changed during the Ice Age and the postglacial epoch, and survive in slightly unlike representative species, as they are called, each of the three grand divisions of northern land, North America, Asia, and Europe, possessing a form thus derived from a common preglacial ancestor.

Professor Gray has conjectured that Asia may have been still united by a land passage with Alaska during the earlier part of the postglacial epoch; but he believed, from the noticeable contrast between the Arctic flora of North America and that of Greenland, that there has been no postglacial connection of land across Baffin bay nor Davis strait.[26] This contrast seems chiefly attributable to the glacial extinction of species in Europe which survived

[26] Articles before cited: and Am. Jour. Sci., II, vol. xxxiv, p. 144; Scientific Papers, vol. i, pp. 122–130.

in North America as before noted, and to the extension of the impoverished European flora to the Færöe islands, Iceland, and Greenland, after the vigorous cold and glaciation of these lands had abated. The difference of the plants found on the opposite sides of Baffin bay, presenting a definite break, while elsewhere throughout the Arctic zone they are intermingled as a single continuous flora, with gradual differentiation toward each end, accords with the testimony of the raised beaches of Labrador, western Greenland, and Grinnell Land, with recent marine shells 1,000 to 2,000 feet above the sea, which show that during the Glacial period the Baffin bay region, after having stood much higher than now, as is known by its fiords, sank far below its present level, and during the postglacial epoch has been again uplifted. But the derivation of the plants of the Færöes, Iceland, and Greenland from Europe could not have taken place through the agency of sea currents nor winds, which would the rather favor their coming from America; and therefore botany seems to contribute to geology the proof that the great preglacial elevation of much of the northeastern Atlantic region, unlike that of western Greenland and Labrador, continued through the Ice Age, the spaces which are now sea between Greenland and the British Isles having become submerged, as pointed out by James Geikie, during the Recent epoch, after affording a land passage for the European flora.[27]

Arctic and boreal plants were driven south during the Glacial period to the central part of the United States, and at its close they followed the receding ice-sheet and again took possession of the great northern region from which they had been expelled. With the restoration of a temperate climate throughout the northern United States and southern Canada, the Arctic species found themselves no longer able to survive there, excepting on the cool hights of mountains, notably the White mountains and the Adirondacks, and, in the case of a few species, on the cool, high northern shores of lake Superior and on the adjacent Isle Royale. These stations of Arctic plants are divided by several hundreds of miles from their general northern range; but they all are readily accounted for as remnants of the circumpolar flora which was forced to migrate alternately southward and northward by the climatic changes of the Glacial and postglacial epochs.

[27] Prehistoric Europe, pp. 518–522, and p. 568, with plate E.

Countries bordering the North Atlantic have experienced generally warmer temperatures than now, both of the sea itself and of the air and winds upon the land, for a considerable time since the Glacial period, apparently extending, but probably in diminishing degree, nearly to our own day. On the coast of New England and the Eastern Provinces, colonies of southern species of marine mollusks are found in Casco and Quohog bays, Maine, and even in the southern part of the Gulf of Saint Lawrence, such as are common along the warmer shores south of cape Cod, but whose continuous range does not pass north of Massachusetts. These isolated southern species include the oyster (*Ostrea virginiana* Lister), quohog (*Venus mercenaria* L.), *Pecten irradians* Lam., *Ilyanassa obsoleta* Stimpson, *Urosalpinx cinerea* Stimpson, and others. Professor Verrill believes that they are "survivors from a time when the marine climate of the whole coast, from Cape Cod to Nova Scotia and the Bay of Fundy, was warmer than at present, and these species had a continuous range from southern New England to the Gulf of Saint Lawrence."[28] Furthermore, we have to note that oyster and quohog shells are found in abundance in the Indian shell-heaps on the coast of northeastern Massachusetts and on islands in Casco bay, Maine, where they are thus known to have flourished in very recent times, though now they are rare or extinct in the same localities.

A few southern plants also survive from this warmer period on or near our northern Atlantic coast, as the *Magnolia glauca* L., which grows on Cape Ann, but not elsewhere north of the vicinity of New York city, and *Rhododendron maximum* L., which occurs rarely in damp woods, somewhat inland, from Nova Scotia to lake Erie, but is very common through the Alleghanies in the southern states. Even northward to Greenland evidences of such a warmer postglacial climate are found, and an increase of cold seems to have made the shores of that land more inhospitable since its first colonization by Scandinavians, only about nine hundred years ago. On the shores of Iceland, Scotland, northwestern Europe, and Spitzbergen, similar isolated southern marine shells are also found, either still living or fossil in postglacial deposits; and the successive floras fossil in the peat-bogs of the land likewise tell of a formerly milder climate.[29]

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[28] Am. Jour. Sci., III. vii. pp. 134-8, Feb., 1874.
[29] Prehistoric Europe. chapters XX and XXI.

But no such evidences of climatic alternations since the Glacial period are discovered in the interior of North America, as in the range of species of plants in the basin of the Red river of the North. Instead, we see there in numerous southern stations of boreal species, indications of the gradual amelioration of the climate through the postglacial epoch to the present day. In Siberia, too, the frozen bodies of mammoths show that a continuously cold but probably ameliorating climate has been uninterrupted by any warm interval since the Glacial period. The recently warmer climate of the northern Atlantic countries, from New England to Greenland, Iceland, Scandinavia, and even Spitzbergen, seems therefore referable to formerly greater volume of the warm Gulf Stream, rather than to any astronomic conditions which would affect not only that ocean and its shores but also the central and northwestern portion of our continent and northern Asia.

The foregoing lines of evidence converge to the conclusion that the cause of the Glacial period was great uplifts of the glaciated areas, probably in conjunction with important changes in the course and volume of the warm oceanic currents. Elsewhere (in an appendix of Wright's "Ice Age in North America") I have endeavored to trace the more remote conditions producing these uplifts, and thereby have accounted, as it seems to me satisfactorily, for the widely distributed areas of Quaternary glaciation, both continental and of mountain districts, for the recurrent advances of the ice-sheets of that time, with warm intervals of recession, and for the far separated areas of glaciation in the Carboniferous and Permian periods.

During the later part of the Tertiary era, and at the beginning of the Quaternary, northern lands were raised higher than now; and the fiords and the submarine valleys indicate that, when this uplifting attained its maximum and brought on the Glacial period, North America and northwestern Europe stood 2,500 to 3,000 feet above their present hight. Alaska and Siberia were probably elevated much less, but enough to supply the continous circumpolar land from which the present community of species in northern floras and faunas is an inheritance. The great area of the shallow Arctic ocean from North America and Siberia to Spitzbergen may have been a land surface, as Mr. Howorth supposes;[30]

[30] Geol. Mag., III, vol. vi., 1889, pp. 305-8.

while its deeper portion between Spitzbergen and Greenland would be a mediterranean sea, or possibly became at length a vast lake, with its waters freshened by outflow southward along the remarkable submerged Færöe channel. About midway between the Hebrides and Færöe islands, this channel is crossed near its southwestern end by the Wyville Thomson Ridge, which consists, at least superficially, of drift with glaciated stones, as determined by dredging. In form and material this appears like an enormous moraine or coastal bar of shingle.[31]

The Færöe channel extends from northeast to southwest some 300 miles, with a width of 75 to 100 miles and a depth of 2,800 to 3,800 feet along its bottom; but the soundings to the top of the Wyville Thomson Ridge are only 1,260 to 1,710 feet, and this ridge, varying from five to ten miles in width, stretches completely across the channel. An uplift supplying land connection from France and Great Britain to the Færöe islands and Greenland, such as Geikie believes to have existed, must have exposed a broad belt of what is now the sea bed on both sides of the deep Færöe channel, besides at least the upper part of the Wyville Thomson Ridge; and the depth of the Skager Rack makes it probable that, while the elevation of the land gradually increased, the channel itself was being eroded nearly to its present depth by its tidal currents and waves, until the sea on the north became a lake and the strait its outflowing river. The fresh-water molluscan fossils in the oldest and highest of the postglacial shore deposits of the Baltic in Gotland, Oesel, and other islands, and in Esthonia, succeeded by marine fossils on lower levels,[32] would be explained by such lacustrine conditions, followed by advent of the sea throughout the Arctic area when portions of the belt connecting southwestern Europe and Greenland became submerged.

Not only was the Gulf Stream probably excluded from the the Arctic region by this land barrier, and warded off more than now from the North American coast by the emergence of the Fishing Banks; but there is also considerable reason for believing that the lower portions of the Isthmus of Panama were contemporaneously submerged, with or without closure of the Strait of Florida, carrying the warm equatorial current, wholly or in part, right forward into the Pacific ocean. Depression and uplift in

[31] Proceedings of the Royal Society of Edinburgh, vol. xi, 1882, pp. 638-677, with map.

[32] Geol. Mag., III, vol. v, 1888, pp. 230-1.

different parts of the world have doubtless in a general way compensated each other. Apparently while northern countries were being elevated, the extensive coral island area of the Pacific was undergoing subsidence; and recently uplifted coral reefs on the west coast of South America and in the West Indies attest a large amount (2,000 to 2,900 feet) of depression there during some part of the Pliocene and Quaternary periods, extending in Peru at least, and probably in the Greater Antilles, to the postglacial epoch.[33] Several low passes from ocean to ocean are found in the lake Nicaragua region, on the Isthmus, and in the Atrato river district on the south, at hights from 133 to 300 feet above the sea level;[34] and abundant Pliocene fossils, according to Dr. G. A. Maack, occur in the vicinity of the Panama railroad and at many localities southward to the Atrato, ranging in hight up to 763 feet.[35] If these could be referred instead, as seems worthy of inquiry, to the Pleistocene or Glacial period, allowing geologically brief submergence while the great ice-sheets of North America and Europe were being accumulated, the climatic problem of the Quaternary era would be solved.

The sun's heat has probably been undiminished and practically constant. Evaporation from the sea in the torrid and temperate zones was doubtless as efficient during the Glacial period as now. Precipitation from the great storms of that time, sweeping over the highly uplifted continental plateaus, was snow. instead of rain, through nearly the whole year, while the ice-sheets were growing in area and thickness, as Prof. W. M. Davis has stated;[36] and the amelioration of the climate and departure of the ice appear to have resulted from depression of the glaciated areas, while thus heavily ice-laden, and the turning again of the warm oceanic current into the North Atlantic and Arctic seas.

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[33] A. Agassiz, Bulletin of the Museum of comparative Zoology, at Harvard College, vol. iii, pp. 287-290: W. O. Crosby, "On the Mountains of Eastern Cuba," in Appalachia, vol. iii, pp. 129-142. J. G. Sawkins, "Reports on the Geology of Jamaica," 1869, pp. 22, 23, 307, 311, 324-9. W. M. Gabb, Trans. Am. Phil. Soc., vol xv, pp. 103-111.

[34] Charles Ricketts, "The Cause of the Glacial Period, with reference to the British Isles," Geol. Mag., II, vol. ii, 1875, py. 573-580. Thomas Belt, Naturalist in Nicaragua, sec. ed., 1888, p. 35.

[35] Harper's Magazine, vol. xlvii, 1873, p. 812.

[36] American Geologist, vol. v, pp. 122-4, Feb., 1890.

THE STRUCTURE, CLASSIFICATION, AND ARRANGEMENT OF AMERICAN PALÆOZOIC CRINOIDS INTO FAMILIES.

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(CONTINUED FROM NOVEMBER NUMBER.)

We will now briefly define the families based upon the structure of the calyx, without, however, undertaking to fully define them by adding all the family features that may be discoverable in the vault and column.

GENERA HAVING TWO BASALS.

FAMILY, Dichocrinidæ, Cotyledonocrinus, Dichocrinus, Talarocrinus.

The calyx is obconoidal. Two basals form a cup slightly notched at the sutures. No subradials. Small regular interradials on the truncated top of the first radials. Five, long, radial plates in the first series; succeeding radials small and resting only on part of the upper side of the first radials, the rest being occupied with interradials. Azygous plates, in line with the first radials, of about the same size, supported in a notch at the sutures of the two basals, and followed by the plates of the vault. Vault more or less convex or elevated with a subcentral opening on the azygous side. Column, so far as known, round.

FAMILY, Pterotocrinidæ—Pterotocrinus.

Calyx saucer-shaped. Two basals form an eight-sided shallow disk, notched at the sutures. No subradial. No regular interradials. First radials large, expanding from a wide base and resembling in outline the side view of an expanding bucket. The top of each first radial supports two second radials and part of two more, which rest, in part, upon the first mentioned second radials. Tertiary radials unite latterally around the top of the calyx. Azygous plate rests in a notch at the sutures of the basals, is pointed above and completely embraced by the first radials. Vault pyramidal, pentagonal, the azygous side wider than the others, the top bearing five long, peculiar, paddle-like plates arranged star-like and directed at right angles to the body, with the ends of four arms resting in each of the angles of the five-rayed dome or vault covering. Column round.

FAMILY. Acrocrinidæ—Acrocrinus.

Calyx urn-shaped, composed of plates that increase in size from the basals up. Basals two, comparatively large, forming a ploygonal shallow cup, followed, in Acrocrinus wortheni, by twelve minute, triangular plates all of which are subradial and subinterradial in position; these are followed by twelve larger plates, united by their lateral sides, five of which are radial in position and seven interradial, three of which are in the azygous area; these are followed by a third ring consisting of fourteen plates all of which are subradial and interradial in position except one opposite the azygous side, which is radial in position; a fourth ring consists of sixteen plates, five of which are radial and the others interradial. Above the fourth ring there are two or more radials in each ray separated by interradials, all within the calyx. The number of plates in the calyx of different species varies from 100 to 700. In Acrocrinus shumardi, the type of the genus, instead of four rings of plates, as above defined, there are fourteen or more rings, some of which have twenty-five or thirty plates. Above these rings of small plates there are three to five radials, each series being separated by two or more series of interradials; the azygous area being wider and containing more plates than the others; there are also secondary radials.

The numerous rings of plates, between the basals and the commencement of the continuing series of radials, is peculiar to this genus and family, and, at once, distinguishes it. If the rings were united, they would occupy the position of subradials or subradials and interradials, but such is the arrangement, that we know of no rule, which authorizes them to be treated as if united.

The three families, Dichocrinidæ, Pterotocrinidæ and Acrocrinidæ, having only two basal plates, are widely disconnected, and each one is so far removed from all other families, that no one can be pointed out which is more nearly related to them, or either of them, than another. We can not infer they descended one from another, or that either of them was developed from any particular family of crinoids having three, four or five basals. We may be ever so fond of the theory of the evolution of animals, and the doctrine that embryology reproduces the images of the lines of descent in geological time; but we may stop, when we encounter numerous plates. in the calyx of a crinoid, whose relation and homology with plates in other crinioids, we cannot

understand, until "missing links" are discovered, before professing to have knowledge of the ancestral type.

GENERA HAVING THREE BASALS, NO SUBRADIALS, NO REGULAR INTERRADIALS.

FAMILY, Synbathocrinidæ.—Synbathocrinus.

Calyx small, cup-shaped. Basals three, the two larger equal, pentangular, the smaller one quadrangular. No subradials. No regular interradials. Radials one to five, truncated and thickened above. Azygous plates resting upon one radial and between the brachials forming a straight, narrow series of two or more plates. Brachials resembling the first radials reversed. Arms, five, long, folded together, enclosing a slender probosc is composed of five rows of quadrangular plates. Column round.

FAMILY, Calceocrinidæ.—Calceocrinus, Deltacrinus, Halysiocrinus.

Calyx laterally flattened and hanging down from the column. Basals three, two are equal and form together a lunate piece, and the other plate lies within the concave side, so as to make the long side of the subtriangular or half-elliptical basal disk, plates always anchylosed. The cicatrix for columnar attachment is in a latteral position in the center of the two equal plates, and does not touch the other plate. No subradials. No interradials. Calyx above the base consisting of five to seven plates, four of which are radials of unequal size and irregular arrangement.

GENERA HAVING THREE BASALS, NO SUBRADIALS, REGULAR INTERRADIALS.

FAMILY, Actinocrinidæ.—Actinocrinus, Alloprosallocrinus, Agaricocrinus, Amphoracrinus, Batocrinus, Dorycrinus, Eretmocrinus, Gennæocrinus, Megistocrinus, Physetocrinus, Saccocrinus, Steganocrinus. Strotocrinus, Teleiocrinus.

Calyx varying from concave as in Agaricocrinus, to obconoidal as in Actinocrinus. Basals three, equal, having a hexagonal outline. No subradials. Primary radials three to five, secondary radials more or less numerous, tertiary radials in some genera. Regular interradials more or less numerous, the first one resting upon the upper sloping sides of the first radials; sometimes intersecondary and intertertiary radials. Azygous area larger than the regular interradial areas, the first plate resting upon the bassls, in line with the first radials and of similar form. Column round.

The learning in regard to the respiratory openings in this family is well illustrated by the statement of Wachsmith and Springer, on page 11, pt. 1. of their work, that they had "noted the existence of certain pores or openings located between the arm bases and separated from the arm passages by a thin partition. Their number varies from ten to twenty or more. In Batocrinus where they were most conspicuous, there are twenty, no matter whether the species has more or less than twenty arms. They are about one-third the size of the arm passages, with which they are in very near the same horizontal plane." And the statement, on page 511, pt. 2, where they say, in this they "were evidently in error; the pores probably always agree in number with the arms, and are really neither radial nor interradial, but are placed at the base of the arms."

FAMILY, Platycrinidæ. Coccocrinus, Cordylocrinus, Eucladocrinus, Macrostylocrinus, Marsupiocrinus, Platycrinus.

Calyx subglobose to urnshaped. Basals three, two of them equal, the other smaller, forming a pentagonal disk or cup. No subradials. First radials very large, forming the greater part of the test of the calyx, the upper face of each bears a short or concave facet, for the articulation of the second radials. Second and also third radials, when they exist, small and short. Interradials and azygoin interradials rest upon the first radials and are substantially alike, in the different areas. Column round or elliptical.

In Macrostylocrinus, there are three to five primary radials, and the first interradials are between the second primary radials; smaller interradials occur between the third primary radials, all of which form part of the calyx, below the arms, and, in this respect, it differs from other Platycrinidæ, where the interradials do not connect the second and third primary radials, and approaches the structure of the Actinocrinidæ. It has little structural affinity with the Melocrinidæ which have four basals and to which Wachsmuth referred it. But Wachsmuth disregarded the number of basals to a great extent, in arranging and defining the families, and his definitions are so loose that crinoids belonging to distinct and widely disconnected families may be thrown together in hodgepodge. For example his definition of the Melocrinidæ is as follows:

"Melocrinidæ. Base monocyclic. Basals three to five. Neither anal nor interradial plates touching the basals; the latter

in contact with radials only. Interradial areas composed of numerous plates; those upon the dorsal side large, regularly arranged, those along the ventral surface frequently small and irregular. Oral plate generally surrounded by proximals. Anus subcentral. Column circular rarely angular."

FAMILY, Dolatocrinidæ.—Allocrinus, Dolatocrinus, Hadrocrinus, Stereocrinus.

Calyx basin-shaped or somewhat hemispherical, depressed at the base. Basals three, usually anchylosed so as to create doubt as to the number. No subradials. Primary radials two or three to five; secondary radials two or more by ten; tertiary radials sometimes present. Azygous and regular interradial areas alike. Interradials three or more, the first, resting between the upper sloping sides of the first radials, the larger and generally the largest plate in the calyx, truncated on top for the second interradial which bears smaller plates. Arm openings large. Small subcentral proboscis. Column round.

Wachsmuth and Springer refer the genera, in this family, to the Melocrinidæ. Dolatocrinus was supposed by Lyon to have five basal plates but Wachsmuth and others assert it has only three, and it is upon their statement, in this regard, that this family is founded, for I have never seen a specimen that preserved the basals, though I have imperfect specimens of Dolatocrinus lacus and would guess from an examination of them that they have only three basals.

FAMILY, Arthracanthidæ.—Arthracantha.

Calyx cup-shaped. Basals three, subequal, having a hexagonol outline. No subradials. First radials subequal, very large, forming the greater part of the test of the calyx, each one thickened in the middle, and having a concave, ridged facet for the articulation of the second radial, which is a short quadrangular plate, reaching but little above the margin of the first radial; third radial short, pentagonol, and bearing the free arms. Regular interradials consist of three zones of three or four plates each, in each area, resting upon the first radials and between the second and third interradials. The middle plate in the zone resting upon the first radials is the larger one, and the plates on eitner side of it are larger than those above; The first azygous plate rests upon two basals in line with the first radials, and is nearly as large, but

a little narrower at the upper margin, which is on a level with the first radials. Above this plate in the azygous area there are three zones of plates; in the first zone there are six and in succeeding zones seven. Column round. All the plates of the calyx bear articulating spines, the bases of which are perforated with minute circular pits as in the Echinida, and as Hambach determined in some Blastoidæ. This character alone is probably of family importance, as it is not known to exist in any other family of crinoids living or fossil. Otherwise the basals, first radials, and first azygous plate, would ally it with the Actinocrinidæ and the plates above with the Platycrinidæ.

Wachsmuth and Springer classed this family with the Dichocrinidæ and Pterotocrinidæ in one family which they called Hexacrinidæ. There are not three families, in my opinion, farther removed from each other, in all the Palæocrinoida. Their family definition is as follows:

"Hexacrinidæ. Base monocyclic. Basals two or three. First anal plate resting on basals, and similar in form to first radials: other plates arranged as in Platycrinidæ. Calyx with similar arm-like extensions. Column circular."

Let us see what there is in this family definition. 1. They say, "base monocyclic." So is the base in every crinoid that has no subradials. In other families, they include monocyclic and dicyclic crinoids which embrace nearly the whole order. 2. "Basals two or three." This disregards the number of basals as a family character, and, in another part of their work, they say the number of basals cannot be considered as of family importance; and yet crinoids having only two basals are unknown in rocks as low as the Devonian, and Arthracantha is exclusively a middle Devonian genus. 3. "First anal plate resting on basals, and similar in form to first radials." It is the same in the Actinocrinidæ. 4. "Other plates arranged as in Platycrinidæ." Such is not the case in the Pterotocrinidæ, by any stretch of the imagination. 5. "Calyx with similar arm-like extensions." This cannot be true, for they include arms constructed of single and double series, arms widely separated and closely compacted; arms free flowing and those confined in interbrachial angles, and, in short, almost every form is represented. 6. "Column circular." This is the case in nearly every family.

GENERA HAVING THREE BASALS. SUBRADIALS. NO REGULAR INTERRADIALS.

FAMILY, Ichthycrinoidæ.—Icthyocrinus, Lecanocrinus, Mespilocrinus.

Calyx obconoidal to subglobose. Basals three of unequal size. Subradials five, pentagonal and hexagonal. Primary radials two, three or four to five. Secondary radials more or less numerous, and higher bifurcating series abutting laterally. No regular interradials. Azygous interradials usually absent in Ichthyocrinus, one subquadrangular and resting upon the larger basal as in Mespilocrinus, or two, one of which rests obliquely in the angle formed by the upper sloping sides of two subradials on the right, and the other truncating the subradial on the left as in Lecanocrinus.

FAMILY, Ampheristocrinidæ.—Ampheristocrinus, Closterocrinus(?)

Calyx obpyramidal. Basals three, two truncated on top, the other much smaller and angular above. Subradials five, two hexagonal, two pentagonal and one heptagonal, the latter the larger one. Primary radials one in each series, with a small central concavity for the reception of a second plate, as in Platycrinus. No regular interradials. Azygous area large, having six or more plates; the first one rests obliquely upon the right upper sloping side of the heptagonal subradial and the under sloping side of the right first radial, the second one truncates the same subradial and these bear smaller interradials. Closterocrinus is referred with some doubt to this family. Wachsmuth referred Ampheristocrinus to the Cyathocrinidæ and did not mention Closterocrinus.

GENERA HAVING THREE BASALS, SUBRADIALS, AND REGULAR INTERRADIALS.

FAMILY, Taxocrinidæ.—Forbesocrinus, Onychocrinus, Taxocrinus.

Calyx saucer to cup-shaped. Basals three of unequal size. Subradials five, unequal. Primary radials more or less numerous, the first one sometimes reaching as low as the basals and completely disconnecting the subradials. Regular interradials from one to twenty or more. Azygous area larger than the regular interradials areas and plates more numerous; the first plate in some

genera truncates a subradial, and in others rests between the upper sloping sides and the first radials.

In Taxocrinus subovatus, the basals form a pentagon extending beyond the column, the subradials are small triangular plates separated from each other, so as to allow the first radials to rest upon the basals ot the central part, with under-sloping sides abutting the adjacent subradials.

GENERA HAVING FOUR BASALS. NO SUBRADIALS. REGULAR INTERRADIALS.

FAMILY, Eucalyptocrinidæ.—Eucalyptocrinus, Hypanthocrinus.

Calyx bowl-shaped to obconoidal with depressed base. Basals four, one larger than the others, deeply sunken in the basal cavity and developed in the interior. No subradials. Primary radials three to five; secondary radials two to ten; tertiary radials one to twenty. Interradials three; the first one is the largest plate in the calyx and always has ten sides; the other two are separated by a vertical suture and their upper ends extend to the top of the tertiary radials, where they support long, flat, interbrachial plates; intersecondary radials, in form like the upper regular interradials, in like manner extend to the top of the tertiary radials and support long, interbrachial plates. Azygous area like the other interradial areas. Interbracial plates extend from the top of the interradials as high as the arms reach, where they unite with the summit plates. Column round. After a re-examination of the fossils, I think the genus Hypanthocrinus should be restored to receive those forms with a proboscis extending beyond the arms and summit plates.

FAMILY, Melocrinidæ.—Compsocrinus, Mariacrinus, Melocrinus, Tecunocrinus.

Calyx bowl-shaped to obconoidal. Basals four, unequal. No subradials. Primary radials three to five; secondary radials more or less numerous, and sometimes, as in Compsocrinus, many tertiary radials. Interradial, intersecondary and intertertiary areas more or less flattened or depressed. First regular interradial resting upon the upper sloping sides of the first radials, followed by two plates and these by three, above which the plates are more or less numerous. Azygous area wider than the regular areas, the first plate resting upon a basal or between the first radials, and gener-

ally followed by three plates and these by three or four, above which, they are more or less numerous. Vault variable. Column round as in Melocrinus, or quadrangular with depressed sides as in Compsocrinus. It is not without some doubt that Compsocrinus is referred to this family, because the azygous side, upper part of the calyx and the column are quite different from all other genera. Technocrinus is also doubtfully referred to this family, because in it, the azygous area is like the other areas, and the upper part of the calyx is widely different from Melocrinus.

FAMILY, Xenocrinidæ.—Xenocrinus.

Calyx obpyramidal, sides depressed. Basals four, unequal, uniting at the angles of the column. No subradials. Primary radials three to five, long, flanged on both sides; secondary radials four or more in each series of the same form. Interradial and inter-secondary radial areas depressed and covered with numerous very small plates. The first interradial generally rests upon a basal but in some cases it is separated therefrom by a narrow prolongation of the flanges near the lower part of the first radials, and hence rests upon the lower part of and between the first radials. Azygous area contains a vertical series of long plates, nearly as long as radials, in its central part supported upon a basal plate and extending beyond the calyx; and on each side of it there are numerous very small plates, as in the regular interradial areas. Column quadrangular, but sometimes becoming round below. Columnar canal pentagonal.

GENERA HAVING FIVE BASALS, FIVE SUBRADIALS, NO REGULAR INTERRADIALS.

FAMILY. Cyathocrinidæ.—Abrotocrinus, Arachnocrinus, Bursacrinus, Carabocrinus, Cyathocrinus, Graphiocrinus, Palæocrinus.

Calyx saucer, hemispherical or bowl-shaped, depressed below. Basals fine, equal, varying from a flattened disc to a cone in the interior of the calyx. Subradials five, large. Primary radials one to to five, large, the one on the right of the azygous side usually the smaller one, truncated on the top, and usually having a concave facet in the centrel part of each for the support of the brachials; but in Abrotocrinus, Bursacrinus and Graphiocrinus the articulation is upon the whole upper horizontal face, as in Poteriocrinidæ, with an external gaping suture. No regular interradials. Azy-

gous plate resting upon the upper edge of a subradial and between two radials. Column round or pentagonal.

Carabocrinus is included in this family on the supposition that Billings was mistaken in saying the azygous area has three plates instead of one. If, however, his diapnosis was correct the genus would belong to another family.

I have separated from the Cyathocrinidæ the Poteriocrinidæ on the ground of the increased number of plates, and the fact that one of them rests upon two subradials and another upon one; confining the Cyathocrinidæ to those having a single azygous plate truncating a subradial. If this distinction is not of family importance, then the Poteriocrinidæ to those having a single azygous plate truncating a subradial. If this distinction is not of family importance, than the Poteriocrinidæ should be associated with the Cyathocrinidæ, as most authors have done. As a generel rule the calyces of the Poteriocrinidæ are obconoidal from the attachment of the column up, and the bases of the Cyathocrinidæ are sunken, giving the calyces a bowl-shaped, but this rule has its exceptions, so that families cannot be based upon it.

FAMILY, Poteriocrinidæ.—Atelestocrinus, Barrcrinus, Cœlicrinus, Euspirocrinus, Homocrinus, Hydreionocrinus, Poteriocrinus, Scaphiocrinus, Vasocrinus, Zeacrinus.

Calyx obconoidal to bell-shaped. Basals five, equal, forming a flattened disc or low pentagonal cup, with high angles between the subradials. Subradials five, unequal. Primary radials one to five, horizontally truncated upon the upper face for the articulation of brachials. No regular interradials. Azygous interrrdials two or more, the first one resting between two upper sloping sides of subradials and below the under sloping side of the first radial on the right, the second one abutting upon the first, truncating a subradial and abutting upon the first radial on the left. In such genera as Barycrinus, this plate also abuts upon the first radial to the right and extends to the top of the calyx. But in genera having three azygous plates, the third one rests upon the first, abuts upon the second one on the left and the first radial on the right; and if a fourth plate exists it rests upon the second, abuts the upper part of the first radial on the left, and the first brachial, and the third azygous plate on the right. Where three or more plates form part of the calyx, they are arranged alternately in

two rows, and continue into, and form part of the ventral sack or proboscis.

I have classed Hydreionocrinus and Zeacrinus in this family with some doubt. They differ in the general construction of the vault and in the arrangement of the azygous plates from other genera, and probably they constitute a separate and distinct family; though I believe all American authors have classed them with the Poteriocrinidæ.

FAMILY, Dendrocrinidæ.—Dendrocrinus, Ottawacrinus.

Calyx obconoidal. Basals five, equal, forming a low pentagonal cup. Subradials, five, unequal. Primary radials one to four and one to two horizontally truncated or having a concave facet for the articulation of the arms. No regular interradials. Azygous interradial, one, truncating a subradial followed by a double series of plates that graduate into the proboscis. This family is distinguished from the the Cyathocrinidæ and Poteriocrinidæ by having two primary radials on the right of the azygous plate instead of one. Otherwise the form of the calyx is like that of a Poteriocrinus and the azygous plate like that of a Cyathocrinus. The many species of Dendrocrinus and variety of forms lead to the separation into a family for convenience of classification, beside, no Poteriocrinus is found in the lower Silurian rocks, where Dendrocrinus prevails, and only one rare genus (Euspirocrinus) referred to the Poteriocrinidæ exists in the rocks of that early age.

FAMILY, Eupachycrinidæ.—Æsiocrinus, Delocrinus, Eupachycrinus, Ulocrinus.

Calyx somewhat hemispherical, flattened or depressed at the base. Basals five, equal, sometimes forming an interior cone. Subradials five, very large. No regular interradials. From one to three azygous interradials, when only one exists, it truncates a subradial and rests between first radials, as in Cyathocrinus, but when two or more exist they are arranged much like they are in Poteriocrinus, though the first plate situate between the upper sloping sides of the subradials and below the primary radial on the right, may be larger than a primary radial, which is never the case in the Poteriocrinidæ. The primary radials are truncated at the upper edge, and have a straight hinge line from one junction of the plates to another, for the articulation of the first brachial plates which are generally spine-bearing. The primary radials

when viewed from the interior are arched over part of the visceral cavity, but as seen from above, they extend beyond the articulating hinges toward the center of the vault as a platform upon which the proboscis is supported. There are no vault plates in this family. The azygous plate at the top of the calyx, extends its flange over the visceral cavity like a primary radial, and supports a series of plates that make a azygous side to the proboscis. I have placed, in this family, genera differing in the azygous area and in the number of azygous plates, but the calyces are similar in form otherwise, and the primary radials are alike in the articulating hinge, for the brachials, and flattened surface or platform within for the support of the proboscis, which I consider of high importance in the structure of the internal anatomy. The column is round, the columnar canal five-rayed, and in the interior of the calyx it is surrounded with muscular scars, and the basal plates are anchylosed in all specimens I have examined in this family.

Wachsmuth and Springer referred this family to the Cyathocrinidæ in the first part of their book, but in the third part they refer the genera to the Poteriocrinidæ.

FAMILY, Erisocrinidæ.—Erisocrinus, Menocrinus, Stemmatocrinus.

Calyx somewhat hemispherical or globose. Basals five, equal. Subradials five, equal. Primary radials five, equal. No regular interradials. No azygous interradials. In Erisocrinus and Stemmatocrinus the primary radials have the form of those in Eupachycrinidæ, but in Menocrinus they are like those in Cyathocrinus. This family is distinguished from both, however, by not having an azygous plate within the calyx, which, I suppose, necessarily, involves important structural modifications in the internal anatomy of the animal.

Menocrinus (Lecythiocrinus) adamsi, as illustrated by Worthen, (Ill. Geo. Sur. vol. 7, pl. XXX, fig. 8.) has five basals, but M. olliculiformis, as defined by White, possessed only three basals. White had only a single specimen and some imperfection may have misled him, for if it possessed only three basals, the two species are not congeneric, and the latter could have no near affinity with any defined family, as Taxocrinidæ is the only one having three basals and five subradials.

Wachsmuth and Springer in the third part of their work refer Menocrinus to the Cyathocrinidæ. In the first part of their work

they refer Erisocrinus and Stemmatocrinus to the Cyathocrinidæ, but in the third part they refer them to the Poteriocrinidæ.

FAMILY, Agassizocrinidæ.—Agassizocrinus.

Calyx conical or urn-shaped. Basals five, thick, usually anchylosed, very small internal cavity, in which there are ligamental pitts. Subradials, five, large, thick. Radials two to five. No regular interradials. Azygous interradials, three or four supported upon the basals. In the early stages of life, Agassizocrinus possessed a small column, but in later life even a cicatrix for the columnar attachment is obliterated. I do not use Astylocrinidæ, because it was founded upon Astylocrinus, which is a synonym for Agassizocrinus, and as a generic name falls into synonymy, so does the family name. Wachsmuth and Springer use Astylocrinidæ.

FAMILY, Merocrinidæ.—Merocrinus.

Calyx very low, broad at the base, slighly expanding. Basals five, low, wide. Subradials, five, short, wide. Radials one to four, and one to two, one radial series having two plates, the upper one of which is axillary and supports on its right sloping side a brachial series, and on the left a smaller series that enters into and forms part of a proboscis, and in this respect the arrangement of the plates is like an Iocrinus. No regular interradials. No azygous interradials. Brachials numerous.

GENÈRA HAVING FIVE BASALS, FIVE SUBRADIALS, REGUAR INTERRADIALS.

FAMILY, Gaurocrinidæ.—Gaurocrinus, Retiocrinus.

Calyx obpyramidal, depressed in the interradial and intersecondary radial areas, and having strong radial ridges. Basals five. Subradials five. Primary radials three to five. Secondary radials from two to sixteen to ten. Regular interradial areas filled with numerous small plates resting upon the subradials. Secondary interradials areas filled with numerous small plates. Azygous area larger than the regular areas, and supported by a ridge up the middle series of plates somewhat like a radial ridge. Vault covered by small plates which are continued as a covering over the arm furrows. Column pentagonal with sides more or less depressed.

FAMILY, Rhodocrinidæ.—Archæocrinus, Goniasteroidocrinus, Lyriocrinus, Rhaphanocrinus, Rhodocrinus.

Calyx subglobose or hemispherical. Basals five, forming a flattened disc or developed as a cone in the interior. Subradials five, equal. Primary radials three to five. Secondary radials one to four to ten. Regular interradial areas wide, plates large, the first one resting upon a subradial and between the first primary radials. Azygous area like the regular areas except an occasional extra plate or two without disturbing the general symmetry of the calyx.

It is not without some doubt that Archæocrinus and Rhaphanocrinus are referred to this family.

FAMILY, Glyptasteridæ. — Glyptaster, Lampterocrinus, Thysanocrinus.

Calyx obpyramidal to cup or urn-shaped. Basals five, equal. Subradials five, four of them equal, the other one truncated for the support of the first azygous plate. Primary radials three to five. Secondary radials variable in number in different genera. Interradial areas flattened or convex, plates large, one in the first series, resting between the upper sloping sides of the first radials, two in the second and smaller ones above. Azygous area wider, the first plate resting on a subradial is followed by three plates and these by three, four or more in succeeding ranges.

GENERA HAVING FIVE BASALS, NO SUBRADIALS, REGULAR INTERRADIALS.

FAMILY, Glyptocrinidæ.—Cupulocrinus, Glyptocrinus, Pycnocrinus, Schizocrinus, Siphonocrinus.

Calyx obpyramidal. Basals five, equal. No subradials. Primary radials three or four to five, the last one supporting secondary radials, and sometimes tertiary radials exist within the calyx. Interradial areas more or less flattened. Regular interradials more or less numerous, the first one resting between the upper sloping sides of the first primary radials; this is followed by two plates, and there are three or more in succeeding series. Azygous area wider and containing more plates than the regular areas, though commencing with one between the upper sloping sides of the primary radials.

I am inclined to think that Siphonocrinus should be classed in another family, because the first plate rests upon the basals, and for other structural differences. It is placed here only provisionally.

FAMILY, Cleiocrinidæ.—Cleiocrinus.

Billings described Cleiocrinus as having five basal plates between the first radials, and forming a belt at the end of the column. I reproduced his illustration in North Americal Geology and Palæontology. Wachsmuth correctly asserts that "such a structure has never been found in any crinoid." I believe with Wachsmuth, that the plates supposed to be basals by Billings, are interradials, but beyond this I cannot follow him. He believes this genus had three very small basals and five small subradials and he has given us an illustration of his views which obliterates the columnar canal. I am unable to understand why he should suppose there are three basals and five subradials when such a structure is wholly unknown in the Lower Silurian rocks. Indeed, three basals, five subradials, regular interradials and azygous interradials are known to exist only in three genera, and they belong to the Subcarboniferous age. I suppose Cleiocrinus had five basals and no subradials. And even with this structure, it would be so far removed by reason of the arrangement of the plates constituting the calyx, that it would constitute a distinct family.

GENERA HAVING FIVE BASALS, NO SUBRADIALS, NO REGULAR INTERRADIALS.

FAMILY, Heterocrinidæ.—Ectenocrinus, Heterocrinus, Iocrinus, Ohiocrinus.

Calyx obconoidal. Basals five, unequal. No subradials. No regular interradials. Azygous interradials not reaching the basals, but resting upon the upper sloping sides of the first radials. Primary radials irregular, and varying in number, in the same genus, the right posterior radial, in some cases, resting upon an azygous plate, and in Iocrinus a radial plate supports on its right sloping side a series of brachiæ plates, and on its left a series of quadrangular plates that graduate into and form part of the pro-boscis or ventral tube.

FAMILY, Anomalocrinidæ.—Anomalocrinus.

Calyx saucer or cup-shaped. Basals five. No subradials. No regular interradials. A subquadrangular azygous plate situate between the lateral sloping sides of the two first radials unites with them by a serrated edge and curves over toward the vault. One primary radial in three rays and two in each of the other two rays. The arms are wide apart, and the radials, between the arms, curve

over the edge of the vault. There is only one genus known. The calyx is low and wide, plates large, column large, different from any other known, arms also differing from all others and bearing pinnules only on one side, from one arm bifurcation to the next alternately.

The diagram of Anomalocrinus incurvus, by Meek in the Ill. Geo. Sur. vol. 3, p 327, and reproduced in my work in North American Geology and Palæontology p. 324, is incorrect, if the specimen figured in the Ohio Palæontology vol. 2 from my collection under the same name, belongs to the same species. The columnar canal is large and five-rayed. The second and third azygous plates form part of the vault covering.

FAMILY, Belemnocrinidæ.—Belemnocrinus.

Calyx cup-shaped. Basals, five, large, long, narrow, and of irregular shape, enclosing a very small visceral cavity. No subradials. Radials one to five, smaller than basals. No regular interradials. Azygous plate like a radial in line with them, resting upon a basal between two radials and supporting a ventral sac.

FAMILY, Catillocrinidæ.—Catillocrinus.

Calyx bowl-shaped. Basals five, forming an irregular pentagon; three of the sides being much the longer. Radials one to five, very irregular in form and size; the two larger ones constitute three-fourths of the circumference at the top of the radials, but are narrow below, while the others diminish in width upward. The arms rise directly from the truncated summit of the radials and are quite compact so that some radials support a much larger number of arms than others do; no regular or azygous interradials.

FAMILY, Hybocrinidæ.—Hybocrinus.

Calyx bulged or tumid on one side. Basals, five, large. One plate half subradial in position, in line with four first radials, but not extending quite so high, and bearing upon one upper sloping side a radial, and upon the other an azygous plate which is rounded and crenulated at its distal extremity as well as much thickened. No regular interradials.

FAMILY, Haplocrinidæ.—Allagecrinus Haplocrinus.

Calyx cup-shape. Basals five. No subradials. No interradials. No azygous plates. Primary radials two to three plus one to two, with small protruding concave facets in the upper

truncated sides for the attachment of the arms; the upper face of these plates supports five vault plates that form a pyramid over the visceral cavity of the calyx. The sutures of the vault plates are bevelled, shallow in the lower part, wider and deeper above, and truncate the top of the pyramid.

Carpenter regards Haplocrinus as "permanently in the condition of a Pentacrinoid larva with a closed tentacular vestibule." Wachsmuth and Springer, fully agree with him that Haplocrinus is "a persistent larval form, but do not understand how the five large plates can represent the orals in a palæocrinoid." Neither does any other one. The permanent larval form is equally asburd.

Wachsmuth and Springer refer Allagecrinus to the Haplocrinidæ, while Etheridge and Carpenter referred it to the family Allagecrinidæ and I followed the latter in my work on North American Geology and Palæontology; but probably the former are correct.

FAMILY, Pisocrinidæ.—Pisocrinus.

Calyx globular. This family has five basal plates, forming a subequilateral triangle; in the type species, three are triangular and two are quadrangular, but in the American species this is reversed. In the type species, two plates unite in an angle of the triangle and only one side of the triangle is formed by three basal plates, the other two sides each being formed by two sides of the basal plates; but in the American species, two sides of the triangle are made by the sides of three basal plates and one by the sides of two basals. In the second series there are only three plates which form the principal part of the calyx, and they partake of the characters of both subradials and radials; one of them bears upon its upper sloping sides, small, radial plates, and is therefore a true subradial; the other two bear radial plates upon their upper lateral sides, but each is also truncated in the upper central part for a brachial or arm plate and therefore two plates are both radial and subradial in position. There are, therefore, three small true radial plates and two large plates radial in the central part of each, so that the crinoid has only five arms. No radial plate is truncated entirely across the upper face, but in all cases the first brachial or arm plate rests in a socket with a point of the radial supporting it on each side. The column in all known species is round and the plates of the calyx remarkably thick, especially in the lower half.

There is no other American crinoid having basals that form a triangle, nor having five basals followed by a second series of only three plates, nor having a second series composed of plates both radial and subradial in position.

FAMILY, Edriocrinidæ.—Edriocrinus.

Calyx cup-shaped. The base is solid in Edriocrinus, and, therefore, if it ever consisted of more than one plate, the number is unknown, and it constitutes nearly all of the calyx. There are five radials resting in depressions in the base. No regular interradial.. An azygous plate, in line with the radials, rests in a basal depression and extends as high as the radials, it is followed by a small plate. But little is known of this family.

FAMILY UNCERTAIN.

The fossil described by Hall under the name of Myrtillocrinus Americanus belongs to an undefined genus. The definition of the species is probably incorrect, for in all known palæocrinoidea the rays of the columnar canal notch the basal plates, and this species is figured as having a four-rayed canal and described as having five basals. Probably other specimens will show that it has only four basals, for otherwise, it will be quite anomalous, and in either event, it is not a Myrtillocrinus.

Nipterocrinus was placed by Wachsmuth in the Icthyocrinidæ without knowing the number of basals in the genus, and Zittel referred it to the Cyathocrinidæ upon equally as good grounds. Until we know whether it has three or five basals, any family reference must be provisional and of little value.

Camarocrinus doubtless belongs to a family Camarocrinidæ, but it is so far removed from other crinoids that it may belong to a distinct order. Ancyrocrinus, Aspidocrinus, Brachiocrinus, Coronocrinus, Cystocrinus and Pachycrinus are genera about which very little is known.

A GREAT QUARTZYTE MORE RECENT THAN THE OLENUS-SCHIST.

By N. O. Holst.*

While the author was reconnoitering in the southern part of the district of Vester-botten in 1885, he observed also the exposures of

*From Geologiska Föreningens i Stockholm Bd. II, p. 33, 1889. Translated by O. W. Oestlund.

the Silurian along Ormsjö (a lake) in the parish of Doratea, as already made known by E. Sidenbladh. The Silurian strata continue from this point further northwest along the valley of Ormsjöån, as observed by me last fall. Thus were seen slates containing "orsten" belonging to the horizon of Paradoxides forchhammeri, a few kilometers south of Bredsele on Arksjöån, as well as further southeast at Nyboden. At the first named place were found Agnostus lævigatus Dalm.,[1] A. planicauda Ang., as well as a species of Olenus and possibly still another species of Agnostus; at the latter named place, Agnostus planicauda Ang. and possibly also A. fallax Linrs.

Of special interest are the geological relations at the rather steep mountain, Månsberget, situated two Swedish miles northwest of the Doratea church. Below this mountain a small boulder-covered plain extends down towards Öster-ormsjö, which covers the foot of the mountain. Somewhat further towards the northwest, close to the shores of Ormsjö, at the village Vester-Ormsjö, the Silurian slate is, however, seen to predominate so largely in the moraine that it can here be considered to be *in situ.*[2] Quartzyte, with a west-northwest dip, is exposed in a precipice of about 100 meters above the plain. The rock has much resemblance to the so-called Verndols-quartzyte. It is of a dirty white or gray color, sometimes greenish and at times granular or like sandstone. Somewhat further up the exposure it is more compact and plainly bedded, dipping slightly west-northwest, so that the rock in this direction is found continually lower down. The quartzyte was reported to continue north far up the mountain. And if it reaches the top of the mountain, as is probable, it is at least some two hundred meters in thickness.

Between the exposure of the quartzyte and the boulder-covered plain a slope is found extending southward, characterized by its luxuriant vegetation. The descent of this slope is, in general, some 20–30 degrees, but at times as much as 50 degrees from the level. On this slope, mostly covered with soil, are found pieces of black slate and boulders of "orsten," of which the latter are not rich in fossils, but yet have in certain layers fragments of Paradoxides fossils, as well as those from the Olenus horizon.

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[1] All the fossils have been determined by Dr. G. Holm.

[2] In a piece of schist containing "orsten," brought home was found Agnostus parvifrons Linrs. The specimens from here seem to be smaller than usual.

At several places it can also be seen that the slate and the "orsten," as found in the slope, have about the same dip as the quartzyte. The Silurian deposits here are, without any doubt, connected with those just mentioned at Vester-Ormsjö.

Already in 1885 I made the observation in connection with my visit here "that the slate to all appearance was over-laid by the quartzyte." But I did not wish then altogether to exclude the possibility of the slate being deposited cotemporaneously with the quartzyte, or by faulting had got a lower position in relation to the quartzyte than what it originally had. Although an extensive landslide covers the slope in which the slate is found, yet the slate and the quartzyte came so close together that I already at that time perceived that the true relation of these two rocks could readily be made out, and without very extensive digging.

Fig. 1.

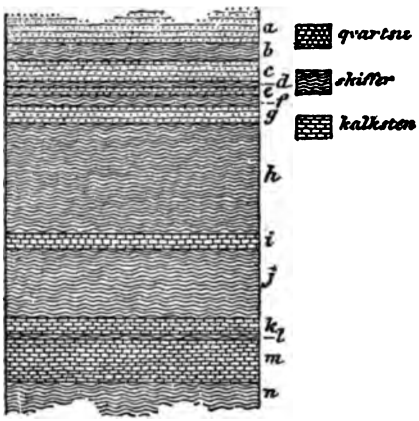


Fig. 1.

a. *quartzyte*, dipping 15° west, continuing up the mountain. *b.* black, soft *schist*, here and there with thin bands of harder, greenish schist, 0.6 m. *c.* *quartzyte*, much broken up into irregular pieces, like *e*, somewhat like "grauwacke," 0.7 m. *d.* dark *schist* (equals *b*), 0.2 m. *e.* bedded, greenish *quartzyte*, much broken, both in large and small pieces. 0.3 m. *f.* dark *schist*, 0.4 m. *g.* a compact layer of *quartzyte*, much broken, 0.6 m. *h.* black, nearly pure *schist*, 4 m. *i.* a layer of limestone, containing "orsten," with *Olenus*, probably, *O. gibbosa* Wahlenb, 0.5 m. *j.* "grauwacke" *schist* (somewhat harder than the higher black schist), 2.5 m. *k.* a layer of limestone with *Olenus gibbosa* Wahlenb.,[1] 0.6 m. *l.* "grauwacke" schist, 0.2 m. *m.* a layer of limestone, 1.4 m. *n.* "grauwacke" schist.

[1] Specimens from this layer are smaller than those from layer *i*.

But at that time I passed the place late in the day, and did not have time to return the following day.

Last fall, when I again passed through the valley of Ormsjö, I decided to make out the relation of the strata by digging, and was surprised when I found how easily this could be done. The section thus obtained is herewith presented.

The slate is often compressed but appears in general to dip in the same direction as the quartzyte. Furthermore, it may be stated that layers of black slate a few decimeters in thickness are seen in the lower part of the *quartzyte* (a), which reminds one strongly of the Olenus slates.

The stratigraphic relations at the Månsberget, therefore, give all indications of *a great quartzyte deposited above the Olenus stratum*, and even seems to pass into it by an alternation of layers.

RECENT OBSERVATIONS ON SOME CANADIAN ROCKS.

By Alexander Winchell, Ann Arbor.

Having recently enjoyed the opportunity to carry on some field investigations in Canada, in a region almost critical in its bearing on some questions at present agitated, I desire to make a record of facts observed, and indicate an incidental question which presents itself for future discussion. The regions chiefly studied on this occasion, lie between the Sault and Echo river; on the east of the head of Great Lake George, in the river Ste. Marie, and in the vicinity of Echo lake, especially on the west and north of that lake. These regions are embraced within the strike of the formation bordering the valley of the Thessalon, and heretofore studied by my brother and myself, as far as Ottertail and Rock lakes. The present observations therefore, serve as a connecting link between our former observations and the eastern shore of lake Superior.

The only previous observations on the same regions which have come to my knowledge, are those recorded in the Report of the Canadian Survey for 1857, made by that sagacious, many-sided and indefatigable explorer, Alexander Murray.* I never follow

**Canadian Report for 1857*, pp. 18–24. See also, Logan's remarks on Murray's results, pp. 6–7; and *Geology of Canada*, 1863, p. 61, and his *Map of the Huronian Rocks*, in the Atlas accompanying this volume.

in Murray's footsteps without receiving an impression of his tireless energy and his quick geological intuitions in working out the structure of regions difficult, as these are, in the extreme.

The whole of the country over which my recent observations extended, is colored by Sir William Logan as Huronian, and reaching from the uppermost quartzites to the "Lower Slate Conglomerates."

The Ste. Marie's river from lake Superior to the head of Great Lake George, pursues a direction a little north of east; but it presents two northward curvatures shaped like an ox-yoke, in the centre of the western of which, the two Saults—the Canadian and the American cities—are situated, and the centre of the eastern of which swells into Little Lake George. Great Lake George is a broad expansion of the river opening out of the eastern extremity of the ox-yoke, as Hay lake opens out of the middle of the ox-yoke—the two forming opposite sides of Sugar island. The immediate Canadian shore of the river Ste. Marie is mostly level and sandy, and without doubt, is underlaid by the lake Superior sandstone, which outcrops at the Sault and in the neighborhood of Gros Cap of lake Superior. At the distance of one or two miles back from the shore, the country becomes rugged, through the presence of successive short ranges of quartzite hills, rendered more pronounced, in many cases, by dykes of diorite and felsite. The quartzite ranges are separated by valleys of hard timber and a fertile soil; and these, within twenty miles of the river, are cleared and cultivated. These ranges continue to the east and southeast of the head of Great Lake George, with a general easterly trend; but, at a greater distance, their trend is more southeasterly; and the entire peninsula between Great Lake George and the "Northern Channel" is occupied by them, as far as the Bruce mines and the Thessalon river.

One who has studied the Huronian quartzites in the valley of the Thessalon, will at once recognize their prolongation in the region east of Great Lake George. Between Ottertail lake and Echo bay is only fifteen miles in a straight line, and in the direction of the strike; and the great white pebbly and reddish quartzites have undergone no perceptible change. It is not necessary, therefore, to give them a full description, in this place. It suffices to state that in the district referred to, they assume a very massive condition, the beds when discernible, being four to eight

feet thick, and outcropping in a succession of terraces—as occurs also in the Thessalon valley. But considerable search is requisite to discover either outcropping steps, bands of deposition or distinct courses of pebbles—the last, though of frequent occurrence, being generally disseminated through the rock.

The other remark which may possess interest, concerns deposits of iron ore in the quartzites. The terrane is extensively intersected by veins and joints. A system of jointage trends nearly east and west, and none of these joints assume the character of veins. But there are many veins and quasi-veins trending N 45° W and N 65° W, which carry encouraging quantities of hæmatite. As regards the filling of these veins, there are two classes. The first class consists largely of a network of veinlets without gangue, diverging and reuniting with a principal vein. The latter, however, has not been seen to exceed four or five inches in diameter; and the whole network, spreading sometimes, over a space ten or twelve feet wide, would scarcely aggregate two feet. The whole contents of the system of ramification is pure, often hard and brilliant, hæmatite.

The other class of iron-bearing veins is accompanied by a voluminous gangue, the whole attaining widths of twelve, eighteen and fifty feet or more. In an opening made on a twelve feet vein, the limiting walls are quartzite, and well defined. The gangue consists of a single material. It is light gray or faintly bluish, finely granular and slightly porous, with a specific gravity of 2.7. Numerous pale pinkish spots are scattered through it, which are generally three millimetres apart and one millimetre in diameter. One sees, under a lens, also, a multitude of minute black particles, sometimes dark reddish, pretty evenly disseminated. It has a hardness between calcite and gypsum, and from that upward one or two degrees. Acids produce no effect upon the substance. Treated for alumina, a variable quantity is eliminated. In some samples, the greater part is alumina; in others, it is silica. No carbonic anhydride is present; but with barium chloride, the reaction for iron peroxide is strong. In polarized light, between crossed nicols, the whole mass is seen to be amorphous or feebly refracting, with an occasional minute grain of quartz; and sometimes a widely disseminated presence of quartz is evinced, but very much disguised by amorphous matter. Throughout are disseminated small irregular individuals perfectly opaque, which are

undoubtedly hæmatite, since a deep red color is developed in grinding the thin sections. This gangue fills the vein-fissure somewhat homogeneously from wall to wall, without any indication of a comb structure.

This substance is in process of change to hæmatite, or perhaps more properly, replacement by hæmatite, though the processes wonderfully simulate transmutation, to the ordinary observer. It begins on the surfaces of joints or fractures, and penetrates into the solid interior. In many places it has proceeded until large masses of hæmatite have been formed. This is occasionally limonitic, but generally, a rich quality of hæmatite, often black and solid. The boundary between the changed and unchanged portions is generally abrupt. The portion immediately contiguous to the hæmatite is not distinguishable from the general unchanged mass. The conviction arises that in course of time, the entire gangue would become iron ore. The change witnessed is of course, within a few feet of the surface; but it does not appear to what extent it depends upon meteoric agencies; nor whether the amount of change accomplished would increase or diminish with depth.

In one location a width of eighteen feet appeared to have completed the change, though in this case, the soft red material contained only about eight per cent. of iron. Along side of this, however, was a rich, vein-like deposit of hæmatite, in places almost specular in its lustre. It may be suggested that the rich, vein-like accumulation in the kaolinic substance, or along side of it, has been derived from the numerous minute hæmatitic particles disseminated through the gray mass, and that the reddened mass is the same after most of the iron has been extracted.

In another instance, the kaolinic gangue material extended over a breadth of fifty or sixty feet, though the soft argillaceous iron deposit was but a few inches wide. The ore is coarsely granular, and the grains possess flattened sides as if by mutual pressure. In spots, the pressure has been accompanied by slight motion which has imparted a slaty structure. The kaolinic mother stuff is similarly granular, and similarly slaty in places. The color of the stuff is pale bluish. The completed change is found to progress from point to point, and a distinct limit is quite conspicuous. In some portions the change is complete, except an island of the greenish gangue, which is thus surrounded on all sides by the completed ore.

These curious deposits appear to occupy fissures in the quartzite, and are limited by walls fairly distinct, and trend in fixed directions, N 45° W and N 65° W. There are no indications of an eruption, either in disturbance or metamorphism. It is not easily conceivable that these deposits should have resulted from any usual condition of irruptive or volatilized matter. It is equally difficult to conceive of its origin from the quartzite, either by segregation or decay. Nor is the case clearer if we apply the hypothesis of infiltration. I am not sufficiently acquainted with mining literature at large to say whether the occurrence is exceptional.

Another mode of occurrence of hæmatite in the Huronian quartzites is in association with diorite dykes. In one instance, a dyke striking N 20° W, and having a width of 400 feet, and composed of long, smooth-faced crystals of hornblende, with a red plagioclase, is accompanied by narrow, irregular veins of hæmatite. The hæmatite is associated with red jasper mostly in the condition of parallel laminæ of not over an inch in thickness. I was not able to ascertain, with facilities for research at disposal, whether the iron and jasper are included in the diorite, or are simply adjacent to it. If included, and not evidently a filled fissure of later age than the dyke, the facts would have some bearing on the possibly igneous origin of some jaspers.

A few miles from this region occurs another diorite dyke, about 30 feet wide, traced over a mile, with a trend N 80° E, wholly granular in texture, composed of hornblende and a dusky red plagioclase with much free hæmatite, and accompanied also, by a multiple vein of hæmatite running along its south flank, and, so far as I could judge, wholly exterior to the dyke. The partial veins are here also, sheathed in laterally by thin plates of red and smoky jasper, all standing vertically, as in the other case, in a position conformable with that of the dyke. This is a position of unconformity with the country quartzite. It follows that the lamination of the ore and jasper has no relation to the bedding of the quartzite, but exists in relation to the walls of the fissure filled by the dyke. The ore and jasper, therefore, came into existence subsequently to the dyke, apparently by infiltration, and it is not difficult to understand how processes of decay and solution may have made the dyke and the contiguous quartzite the sources of the ore and the jasper.

Echo Lake.

Having received oral information concerning the rocks about the head of Echo lake, which produced a half-formed conviction that they are older than the Huronian, I followed the quartzites northward from Great Lake George, across the strike, with unusual interest. The Echo river flows for about four miles, in a serpentine course, across the level and partly swampy border which separates the hilly interior from Great Lake George. No rocks are seen to outcrop along the banks, and it is obvious that the country formation is no longer quartzite. According to Murray, a "slate conglomerate" is seen both on the east and the west of the lower portion of Echo lake, at distances not exceeding two or three miles, and beyond. But, I found, about a mile north of the foot of the lake, evidently at a lower horizon than the slate conglomerate proper, a quartzose range, attaining an elevation of about 250 feet, and traversed by ramifying veins of hæmatite. From a shaft sunk to the depth of about 30 feet, it appears that the formation is in part, a silico-argillaceous slate, and in part a fine grained and semi-vitreous smoky quartzite. Lithologically it is quite distinct from the white or reddish vitreo-granular quartzite further south, and marking the upper portion of the Huronian. It occupies the position of the lower part of the "upper slate conglomerate" noted by Murray and mapped by Logan. On the west shore of Echo lake, within a third of a mile of Limestone point, is an outcrop of dark gray, very fine or vitreous quartzite, which may be an eastward prolongation of that last mentioned. It is not very unlike the flinty quartzite which I have heretofore designated the "Missisagui quartzite" * and supposed to be the lowest member of the Huronian on the Missisagui river. But I do not announce here such an identification. That would necessitate a reconstruction of Logan's map.

A short distance beyond this is the point formed by the outcrop of a bed of limestone. It stands *vis a vis* to another point on the east shore—the bearing from one to the other being S 75° E. The distance across the point, representing the width of the outcrop, is about 330 feet. The beach slope of the exposure covers about 30 square rods; and the surface is amazingly, almost grotesquely, rough, the salient ridges of the more durable laminæ standing out one or two inches above the general surface, being inclined with

* *Sixteenth Annual Report Minnesota*, pp. 167–170.

the dip, and crumpled in an almost incredible fashion. Freshly broken surfaces of the rock reveal lighter and darker, tortuous, but parallel bandings; but the difference in durability of different laminæ would hardly be suspected. The formation on the whole, is a feebly silicious limestone, very hard, fine grained, with innumerable light and dark dun laminæ alternating, and presenting on fresh fracture, a handsome appearance. A vertical dyke of fine-grained, black dolerite intersects the formation, 4½ inches wide, striking N 60° E, with a joint running longitudinally along the middle. As to dip and strike of the limestone, the observations are various. The dip ranges locally from 10° up to 45°; but I concluded that the average dip is not far from 20°; and I shall adopt this as the dip of the Huronian at this place. Such dip is accordant with many observations made on the quartzites higher in the series. The direction of the dip here is about S 10° W.

The outcrop on the east side of the lake is about 500 feet wide. The rock is somewhat less hard. Where blasted into for testing its quality, it is very compact and fine grained, and in places, delicately tinted. The bands are not conspicuous except on weathered surfaces, where thousands of them stand forth, as on the west side. The dip is here locally, 45° toward S 25° E. The mean dip, judging from the strike, is probably about south, on both sides of the lake. The vertical thickness of this limestone would be about 110 feet.

In thin section, under polarizing microscope, this limestone appears strictly fragmental, being composed of minute rounded grains of calcite which, separately examined, are distinctly refractive, and give extinctions on rotation. The dark ribbons and lines are formed by flows of impalpable argillaceous matter, mixed with more or less of the calcitic grains. The same characters are shown by the rock from both sides of the lake. The broken crystals, therefore, of which this limestone was formed, were rolled on the beach with gentle motion, interrupted by intervals of calm, in which the argillaceous particles, the residuum of attrition and solution, were deposited over the bottom. The conspicuous crumpling was evidently the result of later disturbances.

This interesting limestone extends across the country westward, in a prominent ridge; and a little west of Garden river, ap-

proaches within a mile of Little Lake George. Its banded features are here quite conspicuous. A Chicago company has opened a quarry, and is carrying on somewhat extensive operations. The polished surfaces of the banded and of the tinted portions constitute varieties of handsome marble—not clouded like some of that from Vermont, but softly ribboned, and very fine and delicate in texture, and procurable in large blocks.

This limestone does not fully resemble that which I have examined in the vicinity of the old Bruce Mines, with which Murray supposed it a continuation. On Logan's map, it is not connected with the Bruce limestone; though the separation was supposed due to a fault existing along the valley of the Thessalon. But I hold in reserve my opinion respecting their identity. It more resembles the cherty limestone occurring in the vicinity of Ottertail* and at Ansonia**—perhaps Logan's "3k, Yellow chert and limestone," embraced in the quartzite series, and holding a position *above* the "upper slate conglomerate"—not below, as here. This though in places cherty, possesses the fineness and evenness of texture of a lithographic stone. At the Ansonia outcrop, its attitude is disturbed by a dyke of diabase; but it presents the same delicate ashes-of-roses and creamy tints** as on Echo lake and at the quarry near Garden river. The formation at Ottertail dips 28° toward S 58° W, and this amount of dip may be said to characterize the members of the Huronian generally, from the mouth of the Thessalon to Echo lake.

The resemblance to the Ansonia and Ottertail limestones is fully borne out by microscopic characters. The Ansonia rock contains more silicious particles, and a little more disseminated dust of decomposition. But a striking resemblance is seen in delicate argillaceous lines of deposition, and the formation of darker bands, while the general aspect of the one is a faithful picture of the other. At one point, however, the Ansonia limestone is formed largely of rounded calcitic fragments, crossed by very numerous cleavage cracks; and in this condition, some larger grains of quartz are also enclosed. But these comparisons will be pursued on a later occasion.

The very probable identity of the Ottertail, Ansonia and Echo lake limestones must therefore be considered, in spite of their ap-

***Sixteenth Annual Report* of Minnesota Surv., p. 158.

** *Sixteenth Ann. Rep.* Minn. p. 155.

parently different relations to the "upper slate conglomerate"—the former appearing to hold a place *above* the "upper slate conglomerate," and the latter now certainly holding a place *below* it. The position determined for the former—not to speak of Logan's assignment of it to the same horizon—was based by the writer,* on the supposed existence of a fault which had elevated it nearly to a level with the summit of the upper, or white quartzite, while the presence of pebbles of this cherty limestone indicated a position below the lower or red quartzite—some 9,000 feet below its actual position at Ottertail. There was nothing known then, to indicate that it had been uplifted from a still lower level; but, if the Echo lake limestone be its equivalent, the uplift must have been from a level below the "upper slate conglomerate"—that is, an uplift of 9,500 feet, according to my observations of the thickness of the "upper slate conglomerate." So far then, as the petrographic similarity of the Ottertail and Echo lake limestones is admitted in evidence, we have reason for changing the recorded position of the Ottertail limestone—the "3k Yellow Chert and Limestone" of Logan. This change would bring it into the position of Logan's "3e, Limestone," immediately below the "upper slate conglomerate"—a member of the Huronian which I have not seen, unless the Ottertail limestone represents it. As this change would affect not only my own previous determination, but Sir William Logan's as well, I will here merely suggest it for consideration.

Proceeding along the west shore of Echo lake, a high hill rises, crowned with an escarpment, to which I did not ascend, and which has the appearance of quartzite. The next hill, however, I visited, and found the escarpment to consist of quartzite in heavy broken beds, dipping about 20° toward S 40° W, and thus conformable with the Huronian members. The rock is finely granular, with minute disseminated individuals of orthoclase. The distance from the limestone is about 2,640 feet, and this represents a thickness normal to the stratification, of about 900 feet.

Continuing along the northwest shore of Echo lake, we have for the space of three quarters of a mile beyond the last mentioned hill, a range of elevations by estimate about 300 feet high. I am not able to state the facts respecting their geology. Beyond this, however, there is an evident change from the conditions of

*_Sixteenth Ann. Rep._ Minn. p. 168.

the Huronian. The talus of the high hills is made of fragments of hard greenish and blackish slates, not hitherto seen in the Huronian, and among them are huge fragments which lithologically answer the description of the slate conglomerate of the east and north shores of lake Superior. The dips are all very steep. Still further on, is a mass of felsitic quartzite. Beyond this, and northward from the head of the lake, I found a succession of reddish and felsitic quartzite, sericitic quartzose schist, and many fragments of hard slate conglomerate, unlike the "upper slate conglomerate" of the Huronian—the slate being here of a dark, greenish color, considerably warped and twisted, the pebbles ranging from partly rounded to completely smooth, mostly reddish with feldspar, and containing some quartz. Near this, at a higher level, the slate conglomerate is seen in place, very rugged in aspect, standing vertically and striking east and west. It has much the aspect of the Ogishke conglomerate of Minnesota. Still beyond, and at higher levels, we find felsitic quartzite standing vertical and striking N 75° W and N 60° W. On the summit of a hill about 400 feet above Echo lake, the vertical knotted serico-argillitic schist is woven into meshes by half-inch thick quartz veins. Near here are outcrops of hæmatite. Vertical strata of similar character continue growing less conglomeritic and more sericitic; but pebbles do not wholly disappear, and now lie in courses N 55° W. A little beyond, the slate becomes argillitic, and the formation now closely resembles the Ogishke conglomerate. The country varies by turns to more argillitic and more sericitic and more conglomeritic, intersected occasionally by diorite dykes, until we reach the highest summit, where a bed of interstratified hæmatite appears, beyond which, crossing a valley, we find a rugged hill of vertical, dark, slaty argillite—the exact counterpart of the Knife lake argillite of Minnesota. The course of this traverse is directly north from the head of Echo lake, and the air-line distance about a mile.

These changed rocks, in attitudes so strange, cannot belong to the same system with the quartzites, the upper slate conglomerate and the limestone of the Huronian. These rugged strata stand vertically; the Huronian beds dip at an angle of 20°. These rocks strike east, or in a direction approximating that; the Huronian beds strike mostly NE and SW, though with many local variations in these parts. Here is a genuine discordance of strati-

fication. Here are two systems, and not one, as Sir William Logan has mapped them.

A series of convictions now becomes rather clear. We stand here on the veritable formation which, sweeping back of Gros Cap to Goulais bay and Doré river, was identified by Logan, with the Huronian of lake Huron, and fully described in terms which apply perfectly to the rocks here under investigation. We are convinced also, of their identity with the vertical strata in Minnesota and the Canadian Northwest, known as the "Kewatin" system. The same observer brings the facts from remote points into mental juxtaposition, and seems to be in a position to certify to their parallelism.

At the same time, another conviction seems equally clear. *These gnarled, green and pebbly slates are the prolongation of the "Lower Slate Conglomerate" of the Thessalon valley.*

I touch here a question of such fundamental importance that the present occasion will not suffice for its discussion. The outcome has been a surprise, and I desire to pursue the subject at another opportunity.

Ann Arbor, Nov., 1890.

THE BRENHAM, KIOWA COUNTY, KANSAS, METEORITES.

By N. H. WINCHELL and JAMES A. DODGE, Minneapolis.*

II.

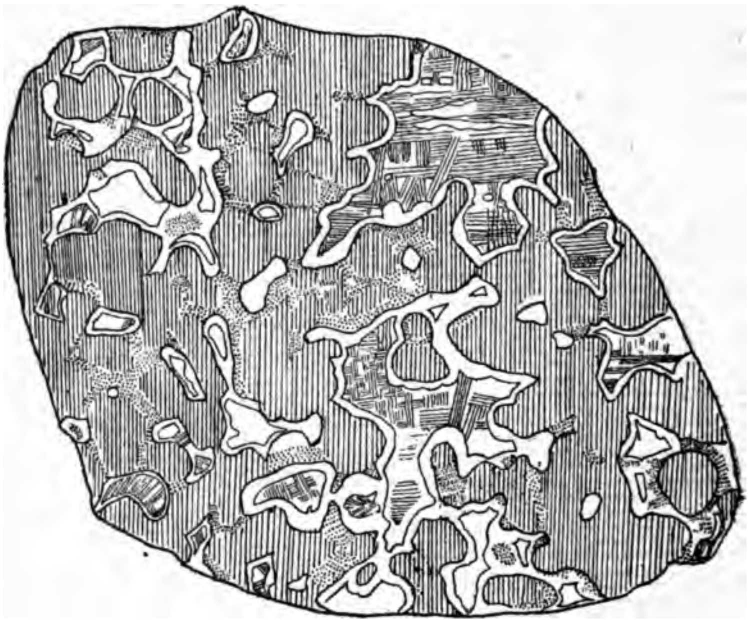
The accompanying plate (Plate VII.) is a "half-tone" reproduction of a photograph made by us of the slab cut from the central portion of the mass weighing 211 pounds. It shows well the distribution of the metallic iron, the specimen having been arranged in such a way that the light was reflected from the metallic surfaces, which appear light in the plate. The blackened condition of the olivine, extending from the surface toward the center

*The first part of this paper was published in the GEOLOGIST, May, 1890, vol. v., p. 309. The discovery of these meteorites was first noticed in the *Topeka Capital*, Topeka, Kansas, March 19, by Prof. F. W. Cragin. They were noted in vol. v., p. 256, of the GEOLOGIST, (April). Since the publication of our first paper Mr. Geo. F. Kunz has described them in *Science*, vol. xv., p. 359, June 13, 1890, and from his paper some comparative facts are derived for this discussion. See also Trans. N. Y. Acad. Sci., vol. ix., No. 8, May–June, 1890, p. 186.

an average depth of about two inches, fading out gradually toward the center and being replaced by the unchanged olivine, is not well shown, but on examining the natural specimen any one is impressed with the great change that has taken place in the mineral, and the great interval of time that must have elapsed since the specimen came within the influence of our atmosphere.

Since the specimen was cut, and while this slab has been exposed to the atmosphere of our office where no acid fumes could have reached it so as to hasten the process, there has taken place a noticeable oxidation all over that part of the cut surface which contains the fresh olivine, viz., about the central portion, and the metallic iron has become rusted to such an extent that it presents a strong contrast with the metallic iron which is nearer the periphery of the slab. This points directly to the nature of the change which has taken place in the meteoric mass. It indicates the loss of some easily oxidizing mineral originally present throughout the mass, or at least its partial conversion into some acid that rapidly attacks metallic iron. On making a closer inspection it appears that the source of this rusting agent is not in the bronzy sulphide mentioned as one of the evident minerals. The red iron-rust surrounds and adheres at the edges of the metallic areas, and even stands up in blisters or minute bubbles, even where none of the bronzy mineral is present. The bronzy mineral is still perfectly fresh generally, and is equally fresh and abundant in the darkened periphery where the change has been carried to completion. In some of the cavities within the spongy iron, from which the olivine amygdules have been dislodged by the process of cutting the specimen, may be seen the thin black film to which we have alluded as giving the iron matrix a botryoidal and specular reflection, and having, when fresh, a silvery metallic lustre, and a hardness of about 3 or 3½. It appears to be this film which furnishes the rusting agent. Some of these films are partially coated with red blisters of iron oxide, although depressed below the general surface and out of the reach of fumes that might have originated elsewhere; they are now either rusty or tarnished or blackened, having lost the bright silvery reflection. In the peripheral portion, however, where the change was so gradual that nearly all the products of the alteration were retained *in situ*, these separating films still present shining surfaces wherever the olivine grains have been removed. The irony product of this alteration seems

here to have entered in the peripheral portion into some of the grains of the olivine, turning them opaque black but not rendering them serpentinous. This was accompanied by a proportionate loss of some of the magnesia, as shown by the chemical analyses below. This rust on the iron is not the result of simple atmospheric oxidation, but has the appearance of iron that has been slowly corroded by some acid, and it indicates that the sulphur in these films is in a different state of combination from that in the bronzy mineral.



Etched surface of the Kiowa meteorite.

On polishing and etching one side of the six-pound piece the distribution of the three principal ingredients (olivine, iron, troilite) were found to be about the same as in the larger mass. The above figure, which is an exact reproduction of that surface, also exhibits the Widmanstättian lines which the etching process brought out on the surfaces of the metallic iron. The barred portions represent the olivine, and the dotted are those of troilite. Some of the metallic iron surfaces do not exhibit the characteristic bars, and generally there is a narrow marginal strip on all these surfaces that does not show them.

For the purposes of analysis three portions of the meteoric mass were selected, namely: first, a portion of the metal; secondly, a portion of the light-colored non-metallic substance; thirdly, a portion of the dark-colored non-metallic substance. These portions were each picked out from a mixed mass of fragments and cuttings obtained in the process of making sections of the meteorite by sawing.

1. *Analysis of the metallic portion.*

Iron	90.48	per cent.
Nickel	8.59	" "
Cobalt	.16	" "
Copper	Trace.	
Phosphorus	.27	" "
Sulphur	.05	" "
Carbon	Trace.	
Silica	.24	" "
Chromic Oxide	.09	" "
	99.88	

The silica and the chromic oxide were found in the residue left on dissolving the metal with nitro-hydrochloric acid. The chromic oxide was in combination with a small amount of iron, as chromite. This, as well as the silica, may have been attached to the surface of pieces of the metal, although pains were taken to remove all such attached matter before analysis. A determination of carbon was undertaken, by Weyl's method. The small amount of residue from the process of solution resembled carbon. But when tested qualitatively, by ignition on platinum foil, only a small part of this residue was consumed.

2. *Analysis of the light-colored non-metallic portion.*

Silica	40.50	per cent.
Ferrous Oxide	10.51	" "
Ferric Oxide	1.77	" "
Magnesia	47.18	" "
Phosphorus	Trace.	
	99.96	

The chemical composition of this portion is evidently that of olivine.

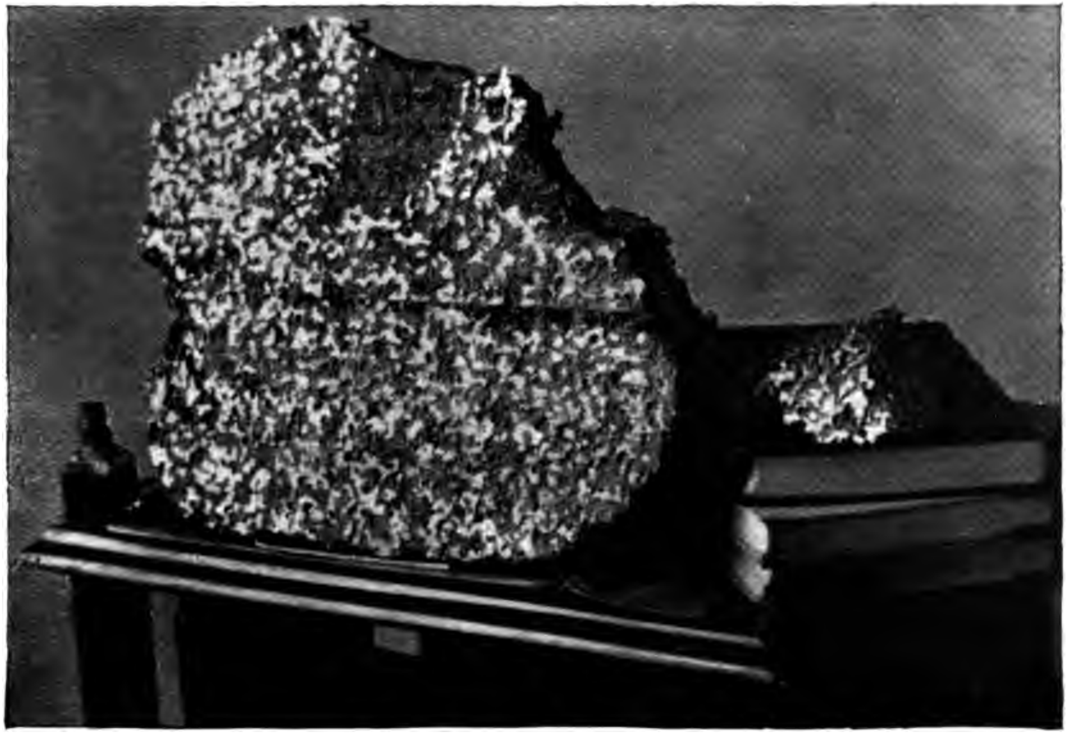
3. *Analysis of the dark-colored non-metallic portion.*

This portion appeared in some respects the most interesting. The pieces selected for analysis varied in size from about one-twentieth to about one-fourth inch in longest diameter. They were of irregular shape, but mostly with rounded surfaces, as broken out of the cellular spaces in the metallic part of the meteorite. Their material appeared to be homogeneous. They

were all of nearly the same color, almost black, surfaces of fracture showing a brilliant lustre. Some were slightly attracted by a magnet. The powder had a dark grey color.

On warming the powder with moderately strong hydrochloric acid, partial decomposition took place, with separation of silicic acid and evolution of sulphuretted hydrogen in small quantity. Qualitative analysis showed the presence of sulphur, silica, iron, nickel, chromium, magnesia and phosphorus. None of the chromium passed into the solution made with hydrochloric acid. In the quantitative analysis, after digesting the powder with hydrochloric acid and evaporating to separate silica, the insoluble residue amounted to 44.3 per cent. This residue had a grey color, such as might be produced by making a mixture of silica and powdered chromite; and this it undoubtedly was. The chromic oxide and the iron in this residue were found to amount respectively to 12.28 and 4.68 per cent. This iron is slightly in excess of the quantity required by the formula $Fe\,O.\,Cr_2\,O_3$. Account of this is taken in the following statement of results. A determination of the total ferrous iron present in the powdered substance was undertaken, by the method of professor Cooke. The operation was carried through in duplicate and the two results agreed very closely. But the powder was not completely decomposed by hydrofluoric acid. The insoluble residue contained chromium and iron, and was again undoubtedly chromite. The amount of iron in the ferrous form found by Cooke's process was 10.19 per cent. Part of this iron is regarded as being combined with sulphur, part with phosphorus and nickel and part, as ferrous oxide, with silica and magnesia. A determination of the total iron in the powder gave 21.21 per cent.

Silica	25.88	per	cent.		
Ferrous Oxide (part),	7.53	"	"	containing iron	5.86.
Ferric Oxide (part),	9.06	"	"	" "	6.34.
Magnesia,	31.95	"	"		
Chromic Oxide	12.28	"	"		
Ferrous Oxide (part) by formula $Fe\,O.\,Cr_2\,O_3$,	5.82	"	"	" "	4.53.
Ferric Oxide (part),	.21	"	"	" "	.15.
Sulphur	1.73	"	"		
Iron combined with sulphur, by formula Fe S	3.03	"	"	" "	3.03.
Nickel,	.65	"	"		
Phosphorus,	.18	"	"		
Iron combined with phosphorus and nickel, by formula $Ni_2\,Fe_4\,P$,	1.30	"	"	" "	1.30.
Total,	99.62			Iron	21.32.



KIOWA COUNTY, KANSAS, METEORITE.

[Original mass weighed 211 pounds.]

As regards the distribution of the iron in the foregoing statement of the results of the analysis, it will be observed that certain assumptions are made. It was, of course, necessary that *some* assumptions should be made. The foregoing arrangement of the results indicates the presence in the material analyzed of four minerals, namely: first, a silicate of composition like that of olivine altered by the higher oxidation of a part of the iron, this mineral making up 74.42 per cent. of the whole; secondly, chromite, amounting to 18.31 per cent. of the whole; thirdly, triolite, 4.76 per cent.; fourthly, schreibersite, 2.13 per cent.

Yet, as previously stated, the material appeared to the eye homogeneous, and a mechanical separation of the above named minerals from the portion taken for analysis would probably have been impossible.

The oxidation which has been mentioned as taking place while the slab has stood in a room at ordinary temperatures, and which seems to indicate the presence of a sulphide besides that of triolite, throws additional light on the probable nature of the minerals that are present, and particularly as to the presence of daubréelite, a sulphide of chromium; and it is here suggested, for future investigation, that the profound change which has taken place in the mass may consist in a conversion of daubréelite to chromite, in the same manner as sulphides of iron are sometimes converted *in situ* on a large scale to oxides. In that case it will be found that the scale which lines the cavities within the iron, in the interior of the mass, surrounding the olivine masses, is a sulphide of chromium, probably daubréelite, * but that in the periphery which shows no accumulation of iron rust since cutting, this scale consists almost entirely of chromite.

The existence of daubréelite as a possible antecedent condition of some of the chromite must remain, for the present, wholly speculative, and the presence of schreibersite is dependent on the necessities of the chemical contents and formulæ.

Microscopic Examination in Thin Section.

We have examined six thin sections. We can detect in them but three minerals, viz:

1. *Olivine*, as indicated by the analysis. This shows all the usual characters of olivine, except that some of the grains do not

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*C. U. Shepard described what he considered a sesquisulphuret of chromium and named schreibersite. but daubréelite has superseded it.

exhibit the brilliant colors between crossed Nicols which are characteristic of this mineral. Its cracks are charged with limonite, and this becomes so abundant in some grains as to render it opaque entirely, in which condition its appearance approaches that of the chromite. When it is fresh it is nearly colorless in ordinary light.

2. *Chromite.* In making the selection of the above analyzed dark, non-metallic portion, it is plain that a considerable amount of this mineral was included. It is found, not only in the outer dark periphery of the slab, but within the fresh central area, and in both cases it is shining black (like anthracite) and brittle. Its fracture and imperfect cleavage are not easily distinguishable from those of the olivine, but it lies in the midst of the fresh olivine grains and does not show any tendency to graduate into them, presenting sharp transitions. It is entirely opaque, but under reflected light its surfaces, in the section, are seen to be specked with numerous particles of troilite.

3. *Troilite.* Throughout the meteoric mass, no less than in the thin sections, are megascopic particles and films of a light-brassy mineral which is that characteristic of meteorites. This forms not only individual masses, sometimes more than a quarter of an inch in diameter, but surrounds and separates the individual olivines. It is opaque, but its ground surfaces, however polished, seem always to be checked and roughened by a fine angular fracture.

It will be noticed that our results differ somewhat from those of Mr. Kunz: whereas the analyses given by him show the presence of a small amount of manganese oxide and ours show none, our analyses indicate the presence of a considerable amount of chromium, and his show none. He also speaks of olivine crystals that "break out entire, the faces on many of them being distinct enough to measure the angles. The spaces from which they break are highly polished, showing every crystal face with a mirror-like polish." We find our olivine masses in rounded forms, embraced, it is true, in brilliantly lined cavities within the metallic iron, but we do not distinguish any individual crystal faces nor exterior angles. We see only the surfaces of cleavages which cause the rapid and easy crumbling of all the olivine grains. Mr. Kunz gives the total weight of the masses that have been discovered at "about 2,000 pounds." He also suggests that parts of this

iron had been made use of by the aborigines, or the mound-builders, as pieces of meteoric iron have been found in the mounds of the Ohio valley.

THE GEOLOGICAL SURVEY OF NICARAGUA.

By J. Crawford, Managua, Nicaragua.

Writers referring to the geology of Nicaragua invariably follow the Spanish statements of the fifteenth century; and declare it to consist of a heterogeneous mixture of materials ejected from volcanoes, like that of other countries of Central America. Its natural history has never been specially examined. This is particularly true of its geology. Two former attempts have been organized for this purpose, but never actually commenced work. This was the situation when, about two years ago, I was leisurely passing through Nicaragua by the usual route from Corinto on the Pacific coast to San Juan del Norte (now America) on the shore of the Caribbean sea. Seeing several rocks and minerals that had been found here, which caused me to doubt the correctness of opinions heretofore entertained, I rather gladly accepted the offer from the Nicaraguan government to superintend for it the collection of specimens of its natural history for exhibition at Paris. To this duty it was soon agreed to add that of examining and reporting on the geology, mineralogy and botany of this country.

The government of Nicaragua gave me the use of the very few instruments it had suitable for my work, also such scientific books in the national library as I might find useful for reference. These books I found to be very antiquated editions of some of the works of Murchison, Lyell, and De Candolle, and some recent publications of Dana, J. P. Cooke and J. H. Wythe. The latter books have been my sole intelligent companions during the greater part of the past twenty-two months.

The belief that Nicaragua was almost all formed from volcanic ejecta was too firmly rooted to warrant the expenditure necessary for an outfit of modern apparatus, instruments and books. We knew that about one third part of the country was occupied only by wild animals, and by the small remnants of three tribes of semi-civilized aborigines, and that the other third part was, outside of a few towns, sparsely settled by miners, cattle rancheros and Indians. Consequently I expected a very rough time, in a moun-

tainous country where pathways were dim, forest dense, population thin, and wild animals abundant.

From the commencement I found the work more than usually attractive, and it became rapidly more and more interesting as the examination developed the geology. I traced the volcanic formations, which form the western and southwestern part, northeastwardly through Quaternary, Tertiary, Mesozoic and Carboniferous eras. These in some places showed evidences of having been affected by volcanic forces, or streams of volcanic rock. Below these, with possibly Devonian and Silurian strata, I then found Eozoic rocks, as bare and bald to the sun as found on the coast of Labrador. My excavations were necessarily limited and hurried, but they revealed evidence of the existence in Nicaragua of a wealth of paleozoic fossils that will, when sought for with greater care, delight the hearts of the future paleontologists of Nicaragua. For twenty-two months I have been actively engaged, almost daily in examining mountains, hills, defiles, valleys, dikes, lodes, soils, etc., ruins, springs, flora and fauna, and have information to enable me to make out a general description of these features of Nicaragua.

Nicaragua, geologically considered, is divisible into five sections.

Section First.

This is the volcanic region, the materials dating from Tertiary and from Quaternary age. They consist of trachytes, basalts, tufas, bombs, breccias, ashes and volcanic mud, the last acting as a cement. There are here also Mesozoic and Carboniferous rocks and minerals, which have been displaced, fractured and greatly changed in appearance by volcanic forces. This section is westward and southwestward, extending to the Pacific ocean, and to Costa Rica. It has a tortuous line, commencing about lat. 13° 15′ N. and long. 87° (west from Greenwich) and extending to about lat. 11° 10′ N. and long. 84° 15′ W., embracing the large lakes Managua and Nicaragua (once a part of the Eocene ocean) and many other lakes which occupy craters of extinct volcanoes. Such crater lakes are Masaya, Nijapa, Tistopa, Giloa, Apoya, Acessosoa, and others, some having fresh water, and others large percentages of sulphates and carbonates, borates, etc. This section has hills, once peaked, now rounded, formed from materials that were the product of volcanoes during times of regular but feeble activity, and elevated plateaus, and long, sloping

plains composed of large and small pieces of igneous rock mixed and hardened with a large quantity of argillaceous sands and volcanic ash. It also embraces wide valleys from 25 to 100 feet in altitude above the Pacific ocean. These are formed in strata, in descending order of,

1. A slightly compacted mixture of vegetable mold and fine-grained volcanic cinders and ashes, from 5 to 15 feet thick.
2. Calcareous materials from two to three feet thick, loosely compacted, or hard, composed largely of remains of shells and crustaceans, some of them being lacustrine and others of brackish-water species, but a large majority of marine.
3. A hardened mixture of sharp-angled igneous rocks, lavas, sands, cinders and ashes, of a depth not yet ascertained, but very deep.*

In this section sulphur (sofatares), paszulano, pumice and obsidian are abundant, and gold, iron ores, lignite, concrete, anthracite are found in some quantities. The anthracite is supposed to be formed by heat from lignite.

The lands in this section are very fertile, and during the rainy season capable of producing large crops. On the elevated plains, 2,500 to 3,500 feet above the Pacific, Ixorea coffea, Cinchonca and other rubiaceous plants are found to perfection.

The following is the approximate altitude of some volcanoes and lakes in this section.

Volcanoes.	*Lakes.*
Viego, 6,160 feet.	Managua, 143 feet (fresh water).
Momotomba, 6,510 feet (smoking)	Tiscapa, 176 feet, "
Caseguina, 3,860 feet.	Nijapa, 168 feet (saline).
Masaya, 3,800 feet.	Giloa, 138 feet, "
Mombacho, 5,100 feet.	Masaya, 415 feet (fresh).
Ometapa, 5,800 feet (hot on top).	Apoyo, 785 feet. "
Madera, 5,000 feet.	Nicaragua, 126 ft. (slightly saline).

None of the volcanoes are active at present. Momotomba emits a little vapor, and is hot on top. Ometape is not quite cool on top, and a rough murmuring sound is heard at its base, becoming now almost inaudible from a very distinct and disagreeable, continuous, grating noise heard there for several months in the latter part of 1887. The water in the lake Nijapa is strongly impregnated with salts, so that a light, copious lather is formed on the heads of persons bathing there. The water of lake Nicaragua

* Also at different depths from the surface are deposits like beds of glacial drift, generally found, at intervals, from a few leagues northwest of lake Managua westward to the Pacific ocean.

contains a sufficient percentage of chlorides, etc., to agree with the Squalidæ, whose teeth are not so lance-shaped as are the marine species. The water in lake Managua contains a much smaller per centum of saline matter than lake Nicaragua, but more than double the per centum of salts in the waters at the mouth of the river Viejo which empties into this lake. Large springs of boiling mineral waters are found in the valley near the western base of Momotomba, also below the falls at Puebla Tipitapa, on the west side of the channel, also on the north side of San Juan river—all containing a large per cent of sulphur, iron, magnesia and alkalies. Mud-floods ("aluvions") have occurred in this section, and sometimes the resulting stratified formation resembles some of beds of the Tertiary so closely as to be very deceptive, and require very careful examination to be distinguished.

Second Section.

This division adjoins and is northeastward from the last, and extends in a northeast direction to a line from about lat. 13° 25′ N. and long. 86° 50′ W. to about long. 86° 35′ W., thence to a very irregular, diagonal, inclined line, to about lat. 11° 35′ N. and long. 83° 40′ W. Its geological formations are.

1. Modern submerged forests, peats, clays, marls, caves, etc.
2. *Champlain* tufas, moraines, clays, striated rocks, glacial boulder clays, drift, erratic rocks, etc.
3. *Pliocene* flinty shingles, loams and laminated clays, lignites, etc.
4. *Miocene* shelly sand, reddish brown, in oblique layers. Marly limestone, greenish, lignite, etc.
5. *Eocene* millstones, limestones and clay (marine); marly limestones (fresh water), sandstones, etc.
6. *Mesozoic*. Septaria beds, marly clays (blue), flinty limestone, green sandstones, limestones (brackish-water), clays, slates and conglomerates, sandstones, sometimes pebbly, gypsum, bituminous earths, etc.
7. *Permian*. Magnesian limestone, limy magnesian marble, etc.
8. *Carboniferous*. Coal, millstone grit, siderite. Mountain limestone, shales, etc.

In this section apatite, jet, opals, agates, onyx, gypsum, talc, steatite, kaolinite, and barite are frequently found, also petrified bones of animals of apparently Tertiary and Mesozoic eras, ; also bituminous coal in at least one place, but slightly disturbed.

No volcanic craters, no lakes nor mineral springs have been noticed in this section. Large areas exist in which are thickly deposited fragments of igneous rocks.

In this section are many large valleys 250 to 750 feet above the Pacific ocean, some of them well watered, but the majority not well watered. It also contains many forests of valuable trees. The average temperature is about 22° Cent. The fact that this section adjoins the great volcanic belt on the southwest, and the Archean area and Silurian formations without volcanoes on the northeast, causes much perplexity when examining about its margins or limits and in describing it even in a general way; especially to distinguish between metamorphism occasioned by heat from volcanic sources, and that by heat developed on the attrition of particles from contraction.

Section Third.

This section adjoins and lies to the northeast of section second, and is bounded on its northeastern side by a line northeastwardly from about lat. 13° 25′ N., and long. 86° 40′ W., to lat. 14° 42′ N., and long. 84° 40′ W., thence southeastwardly to about lat. 12° 40′ N. and long. 84° 30′ W.

1. Gneiss, granite, protogine, porphyry, slates, crystallized limestones, and iron containing titanium, of Eozoic age, are abundant in well defined areas in this section, especially about lat. 13° 37′ N. and long. 86° 32′ W. In some places, notably Cerro Lagoonita (a part of the mesas de Totumble) gneiss of Silurian era is found for miles in length, and over 600 feet nearly perpendicular. It is fractured (schistosed) in nearly vertical lines intersected at nearly right angles by other dividing planes that are often over 100 feet apart. In a few places these division lines, where they intersect, have been expanded into caves which extend 100 feet or more into the mountain. Bones of man and other animals are sometimes found in these caves.*

2. *Devonian*, red sandstones; coarse, gritty shales, spotted marls, etc., are found in and near the edges of this section.

There are in this section a few deposits of kaolin, of an unusually pure kind; also veins 6 to 12 inches wide of crystallized translucent quartz; and in several places large masses of albite-porphyry, labradorite-porphyry, orthoclase and anorthite feldspars; and in many places argillaceous slates, cut by dikes and veins, the latter sometimes rich in gold, silver, lead, antimony and tin. Some of these lodes also contain uranium ores mixed with those of tin—others contain nickel. There are also several large deposits of hematite and limonite; in some of the creeks are found platinum and iridium.

* In reference to bones and caves the Indians tell numerous mythical stories. Some of the crania of man are certainly very early neolithic, or earlier.

In several parts of this section are large elevated plains, and long, gradually sloping cerros, well watered and very fertile. These are from 1,100 to 3,500 feet above the sea, and admirably qualified for the semi-annual production of large crops of wheat, barley, corn, sugar, etc.

None of the mountains exceed 5,000 feet above the Pacific ocean. 2,900 to 4,000 feet are the usual limits of altitude. There are several large mineral springs in this section, some boiling. No volcanoes nor evidences of seismic forces appear. The average temperature of the air is about 20° Cent. and the climate is delightful all the year.

Section Fourth.

This is a strip of territory extending from north to south on the east of and adjoining section third, and extending eastward to within about 100 miles of the Carribean coast. Its geological history is similar to that described in Section second, but its formations have not been so much disturbed. Coal, iron ores and marble are in large deposits; also, near its eastern edge, about the headwaters of the Princ Apulka river, are found rich gold placers. The forest consists principally of mahogany, cedar. pine, walnut, hickory and of Cecropia, peltata, Siphonia elastica, Moras and Cassalpinia echinata. The temperature averages about 22° Cent. The soil is very fertile and watered by numerous creeks and rivers. This section is just west of the coast belt of frequent rains.

Section Fifth

Is a strip north to south on the Caribbean sea coast, a formation of lagoons, deltas, swamps, and brackish-water estuaries, excepting a narrow strip of sand along the sea coast.

Mounds exist on this coast containing stone implements, flint arrow-heads, rough flint spear-heads, and bones of man older than Spanish occupation.

Managua, Nicaragua, Dec. 14, 1889.

NEW LAMELLIBRANCHIATA.

By E. O. Ulrich, Newport, Ky.

No. 3. Descriptions of new species, with remarks on others.

WHITELLA SCOFIELDI Ulrich.

The specimen below illustrated preserves the characters of the hinge in a very satisfactory manner. There are two sharply de-

Whitella scofieldi Ulrich, THE AMERICAN GEOLOGIST, Vol. VI, No. 3, p. 180, 1890.

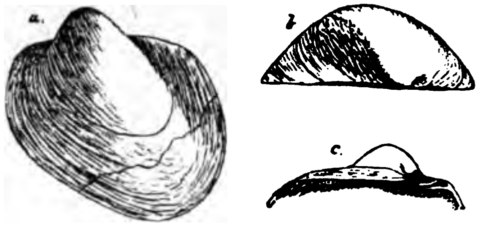

Fig. 16. *Whitella scofieldi* Ulr., Trenton shales, Cannon Falls, Minn., *a*, large left valve, restored in the postero-ventral region. It is possible that the restored portion should be more narrowly rounded. *b*, cardinal view of same; *c*, interior of same to show dentition of hinge, and internal cartilage support within the posterior half of hinge line.

fined oblique teeth situated about midway between the beak and anterior extremity. The narrow depression between them receives the anterior tooth of the right valve, while the second tooth of that valve must have fitted into an elongate depression beneath and in front of the beak of the left valve. A decided ridge-like thickening is to be observed beneath the posterior third of the hinge line. It increases in strength posteriorly, and, as interpreted by me, served as a support to an internal ligament. The escutcheon or external ligamental area is very narrow, though quite deep, and does not extend in front of the beaks. It is also finely striated longitudinally, a feature that probably pertains to all the species of the genus.

Of external features, the large umbones and the tumid appearance of the shell in general, are the most striking, and seem to indicate closer relationship to *W. umbonata* Ulr. (GEOLOGIST, Sept. 1890,) then at first supposed. Another point in which *W. scofieldi* approaches that species, and in which both differ from all the others, is found in the location of the point of greatest convexity, it being behind the middle of the valve. In *W. umbonata* the point is higher up than in the present species, it being almost exactly at the center of the valves in the latter. A more important difference is found in the escutcheon, which in the species *umbonata*, *obliquata*, *sterlingensis* (M. & W.), *hindi* (Billings) and *compressa*, forms a wide channel extending the whole length of the hinge line, while in *W. scofieldi*, it is narrow and does not extend anteriorly beyond the beaks. The next described species (*W. truncata*) agrees with it in that respect.

Several years ago I received, with a number of other fossils, an internal cast of a shell that probably belongs to this species. These fossils were collected at Beloit, Wis., from the Buff limestone of the Trenton, and the cast in question was labeled *Cypricardites megambonus* Whitfield. I do not think that it belongs to that species, the shell being more oblique, and the umbonal ridge more pronounced and angular, agreeing in these respects very closely with the *scofieldi*. Another specimen received at the same time agrees more nearly with the figures of the former (Geol. of Wis. Vol. IV, Pl. 5, figs. 7 and 8.) It is comparatively less ventricose, but being much smaller than the figured specimen, it is possible that the difference is due to age.

But both these specimens are unquestionable *Whitella* and not *Cypricardites* at all, and the question naturally arises, may not Whitfield's species really belong to the same genus? I am almost satisfied that it does, despite the fact that Prof. Whitfield both describes and figures (loc. cit. fig. 7) his species as having "two long, curved, posterior teeth." If his fig. 8, representing an antero-cardinal view of the same specimen, is reliable, and I believe it is, the impressions of the supposed posterior teeth cannot have been produced by teeth at all. When the valves are closed, as is shown to have been the case with his specimen, the teeth must necessarily interlock, else they would miss their purpose. In his figure, however, the impressions are widely separated.

Now, that is just as it should be in a species of *Whitella*, like *scofieldi* or *compressa*, in which the posterior internal cartilage support is strongly developed. In the cast this leaves a long, narrow impression on each side of a ridge, representing the space originally occupied by the ligament.

And there are other reasons that cause me to doubt the generic placement of species *megambonus*. In the first place the shell must have been thinner than in true *Cypricardites*, and without that ridge-like internal thickening which leaves casts of species of that genus marked with a shallow groove running from the umbones toward the postero-ventral margin. Nor are the muscular impressions nearly so distinct as is usual in *Cypricardites* and the beaks are enrolled in a fashion quite foreign to species of that genus. There is, furthermore a fullness and smoothness about the casts that is not equalled by those of any true *Cypricardites* known to me. On the other hand, the casts agree in all respects

with those of species of *Whitella* and until it is proven that the species really possesses posterior hinge teeth, I shall refer to it as *Whitella megambona*.

Whitella truncata n. sp.

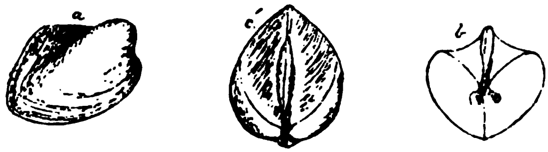

Fig. 17. *Whitella truncata*. n. sp., Galena limestone, Cannon Falls, Minn. *a*, left side of a large cast of the interior; *b*, antero-cardinal view of same; *c*, cardinal view of same.

Shell small, very oblique, ventricose, subrhomboidal in a side view. Beaks nearly terminal, prominent, of moderate size, obliquely enrolled; umbones and umbonal ridge full, the latter angular and traceable to the postero-basal angle. Cardinal slope sharply defined, and distinctly concave; anterior and basal slopes slightly convex and very rapid. Anterior end very short, scarcely projecting beyond the beaks, narrowly rounded, then sloping rapidly backward and uniting very gradually with the gently curved basal margin. Posterior end truncated, straightened, forming nearly a right angle with the hinge line, and one of from 75° to 80° with the ventral edge.

Escutcheon narrow, not extending anterior to the beaks. In casts of the interior, the internal cartilage support leaves two narrow impressions, one on each side of the posterior half of the hinge line. Dentition of hinge not observed. Muscular sears very faint.

Dimensions of a large cast of the interior: Greatest hight, 13 mm.; greatest convexity (near center of shell) 15 mm.; length from beaks to postero-basal angle, 19 mm.; length from anterior extremity to upper portion of posterior margin 15 mm. In a small specimen only 6 mm. high, the other dimensions are in proportion, except that the convexity is comparatively less.

This species is closely related to *W. scofieldi*, but may be distinguished by its smaller size, greater convexity, truncated posterior end, shorter anterior end, and more pronounced postero-ventral angle.

Associated with this species, I found a cast of another species of this genus, reminding one strongly of *W. obliquata* Ulr. It is,

however, not the same as that species, being smaller, more elongate, and with the postero-basal angle sharper. The impressions of the internal ligament supports are also much wider and stronger than in that species. I conclude therefore that it represents a distinct species which might be called *Whitella præcipta*, n. sp.

Position and locality: Shaly layers of the Galena limestone, associated with *Receptaculites* and *Hemipronites americana* Whitfield.

Whitella subovata, n. sp.

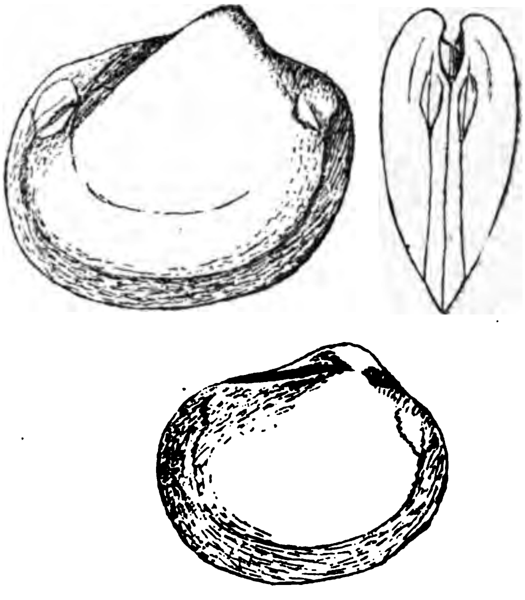

Fig. 18. *Whitella subovata*, n. sp., Cincinn group, Waynesville Ohio. *a*, right side of a large cast of the interior; *b*, profile of same; *c*, right side of a slightly distorted, smaller example of this species, from the collection of Mr. I. H. Harris, of Waynesville.

Shell of medium size, subovate in outline, moderately oblique, and unusually compressed for this genus. Beaks large, prominent, obliquely incurved, situated a little in front of the center of the hinge line. Umbonal ridge distinct above, but never a conspicuous feature of the shell. Cardinal slope narrow and faintly concave; the remainder of the surface gently convex, with point of greatest convexity above the center. Anterior end comparatively wide and long, sharply rounded above, then sloping back-

ward very gently and uniformly into the basal margin; posterior end generally uniformly rounded, but occasionally the basal portion is a little produced. Escutcheon or ligamental area deep and wide, extending to the anterior extremity of the hinge. Internal

Cypricardites grandis, n. sp.

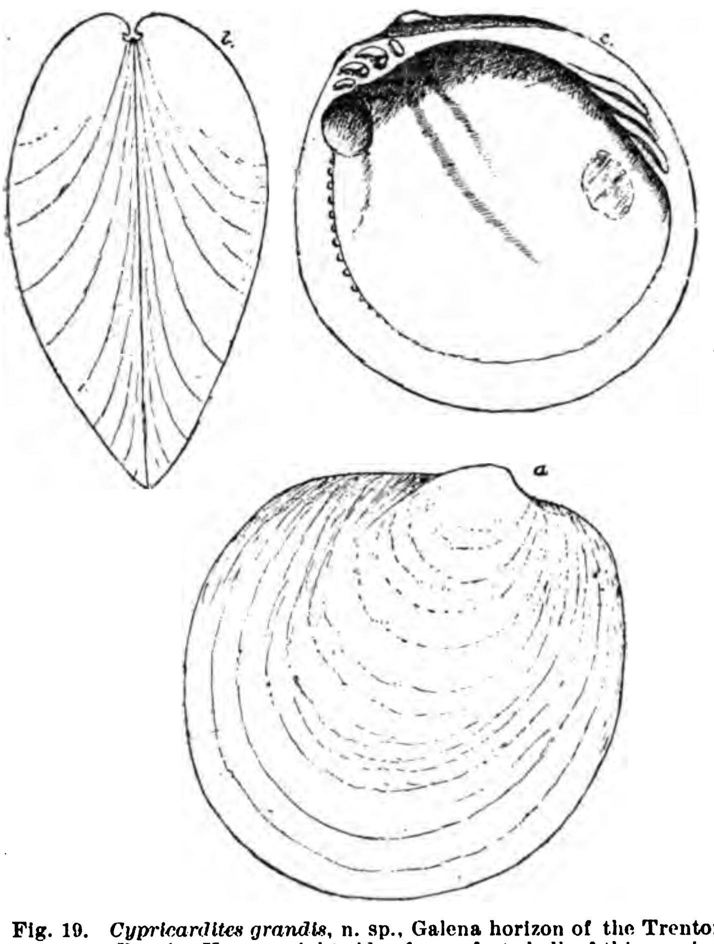

Fig. 19. *Cypricardites grandis*, n. sp., Galena horizon of the Trenton group, near Burgin, Ky. *a*, right side of a perfect shell of this species; *b*, anterior view of same; *c*, interior of right valve as obtained from gutta-percha impressions of casts of the interior.

ligament supports not leaving any appreciable impressions on casts of the interior. Muscular scars and pallial line unusually distinct. Surface with concentric lines of growth.

This species resembles the Minnesota Trenton shales species,

W. compressa, rather closely, but is distinguished from it, as well as from all the others of the genus, by the suboval outline. The casts are not nearly so ventricose as those of *W. obliquata* and *umbonata*, with which it is associated.

Position and locality: Upper beds of the Cincinnati group, at Waynesville, Ohio, and other localities.

Shell large, moderately ventricose, slightly oblique, the outline subcircular. Beaks small, projecting slightly above the hinge line, obliquely incurved, almost in contact; situated about in the middle of the anterior half of the cardinal margin. Umbonal ridge inconspicuous, the slope of the surface to the postero-cardinal margin gradual and slightly concave, the slope to the basal and anterior margins very gently convex; point of greatest convexity a little above the center of the shell. Anterior end longer in front of the beaks than usual in this genus, the margin narrowly rounded above, then with a very gentle and almost uniform downward and backward curve merging imperceptibly into the basal, and later into the posterior margin. Antero-cardinal edge slightly produced; likewise the postero ventral, but in most cases so gently as to be scarcely appreciable. Surface smooth, with fine concentric lines of growth.

Ligamental area deep but appearing narrow in a cardinal view. As usual, it is finely striated longitudinally. Hinge plate strong, with three anterior teeth in the left, and four in the right valve. These teeth are short and abruptly curved down at their posterior ends, terminating with a knob-like projection. In the right valve the first and fourth are much smaller than the second and third; the middle tooth of the three in the left valve is also much the largest. Posterior teeth longer, parallel, and slightly curved, three in the right valve and two in the left. Anterior and posterior muscular scars large, situated just beneath the two sets of hinge teeth, the posterior one rather faintly impressed, the anterior deep. Pallial line simple, only the anterior half sharply defined, and often emphasized by a series of small pits. Inner side of shell with two low, subparallel ridges extending from the beaks two-thirds the distance to the postero-basal margin. The furrow between these appears as a low ridge on casts of the interior. These often present another but much smaller ridge running downward from the inner margin of the anterior muscle scar. In casts the beaks are flattened, very prominent, and not far apart.

This fine species is related to *C. canadensis* Billings, and *C. ventricosus* Hall, particularly the former, but both those species are much more oblique and decidedly ovate instead of subcircular. *C. wortheni* Ulrich, (Ill. Geol. Surv., Vol. 3, Pl. 3, Fig. 9) is also very near, but is more ventricose and less oblique, and has the beaks (in casts of the interior) farther apart, indicating a more massive hinge plate. There is also one posterior tooth less in each valve of that species.

Another close relation is found in the "Buff limestone" of the Trenton at Beloit, Wis. It was sent to me as *C. niota* Hall, but is clearly not that species, being of a more circular shape, and less ventricose, with the surface of the cast also more evenly convex. From *C. grandis* it differs in having the beaks nearer the anterior extremity, and only two instead of three posterior hinge teeth. The latter are also more delicate, and the shell smaller.

Position and locality: Upper beds of the Trenton limestone (Galena horizon), one mile south of Burgin, Ky. It is also to be found at Harrodsburg and other localities, but good specimens are rare.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

A Geological Reconnaissance in southwestern Kansas. By ROBERT HAY. pp. 49; with 2 plates, and 21 figures in the text. (Bulletin of the U. S. Geol. Survey, No. 57, 1890.) A geologic map of the southwest part of Kansas, including the region about Wichita and westward, crossed by the Arkansas river, forms the frontispiece of this report and numerous sections are given in the second plate and in the text. The bed-rocks are Carboniferous shales and limestone, at Wichita and eastward; unfossiliferous Jura-Trias shales, clays, limestone and sandstone, mainly red, estimated 550 feet in total thickness, well developed southwest of Wichita and on the Cimarron river; the Cretaceous series, of which the Dakota, Fort Benton, and Niobrara formations are recognized, extending from Wichita west along the Arkansas to the 100th meridian; and Tertiary grit and marl, apparently the representatives of the Loup Fork and Equus beds of Cope, occupying most of the southwestern quarter of Kansas.

In the upper part of the Jura-Trias is found a noteworthy bed of white gypsum, 12 to 15 feet thick; and beneath the prevailingly red beds of this series, borings pass through some 370 feet of gray shales, enclosing in their lower part several layers of rock-salt from 2 to 11 feet

in thickness, as described by Mr. Hay in the GEOLOGIST, February, 1890. The saliferous beds are referred provisionally to the Triassic system, giving to the Jura-Trias, with this addition, a thickness of more than 1,000 feet in the southern part of this state.

The Quaternary deposits noted in this reconnaissance are five, denominated, in ascending order, gumbo, earlier gravel, loess, later gravel, and alluvium.

On some Relations between the Geology of Eastern Maine and New Brunswick. By L. W. BAILEY. [Transactions of the Royal Society of Canada for the year 1889, Vol. VII (Montreal, 1890) sec. IV, pp. 57-69.] Professor Bailey first gives a general review of the more important papers describing the geology of this region. A remarkable fact is noticed, which was early recognized by Billings and later has been considered by Sir Wm. Dawson, that features are presented by many of the fossiliferous horizons of the East which are very different from those of the more westerly portions of the continent, and show a nearer relationship with those of Europe. The rocks of Deer Island and Campo Bello, which professor Shaler compared with the Cambrian rocks about Cambridge and Boston, are still regarded as Pre-Cambrian and probably Huronian. The Perry group, the flora of which has been so well described by Dawson, is considered to be true Devonian and is said to most nearly resemble the Catskill of New York. It will be remembered that on the maps of the Canadian survey this group was colored as Lower Carboniferous and defined by Bailey and Matthew as "a group of beds lying at or near the base of the Lower Carboniferous series, and characterized by an Upper Devonian flora." (Geol. Surv. Canada. Rep't. of Progress for 1870-'71, p. 200). As a result of the explorations in northern Maine it is shown that large tracts, which had been represented on the maps of Maine as Devonian, are really Silurian. There are, however, localities in the northern part of the state at which Oriskany fossils have been collected.

This valuable paper of professor Bailey suggests the desirability of a field examination of the Perry group by a geologist who is thoroughly familiar with the typical Catskill of New York and Pennsylvania. What might be regarded as a commencement in this work was made by the U. S. Geological Survey in the summer of 1889 when an assistant was sent into northern Maine, under the direction of Prof. H. S. Williams, for the purpose of collecting from the so-called Devonian of that region.

The Glacial Boundary in Western Pennsylvania, Ohio, Kentucky, Indiana, and Illinois. By GEORGE FREDERICK WRIGHT. With an introduction by T. C. CHAMBERLIN. pp. 112; plates 8; figures 10. (Bulletin of the U. S. Geol. Survey, No. 58, 1890). Professor Wright here reports his detailed exploration of the extreme limits of the glacial drift from Pennsylvania to the Mississippi river. Morainic accumulations are not generally developed along this margin of the earlier drift, which is thus remarkably contrasted with the boundary of the later

drift, belonging to the second glacial epoch, found in the Mississippi basin scores of miles and in part two hundred miles or more to the north. The hypothesis of a glacial dam across the Ohio at Cincinnati, which Prof. Wright had previously presented before the American Association and in his "Ice Age in North America," is here more fully considered; but President Chamberlin holds that if such an ice-dam at any time ponded back the water of the Ohio, it was only for brief times, being comparable with ice-gorges of recent spring floods, though on a much grander scale. The terraces of the Ohio seem clearly referable to fluvial action, having slopes of descent much like the present river; excepting certain slender horizontal terraces that have been noted by Mr. McGee, and perhaps others reported by Prof. I. C. White, which may be due to the obstruction of the valley at Cincinnati by the ice-sheet during its stage of maximum advance.

LIST OF RECENT PUBLICATIONS.

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1. *State and Government reports.*

California state mining Bureau; Catalogue of the State Museum, vol. 4. Wm. Irelan.

Annual report of the territorial geologist, Wyoming, Jan., 1890, Louis D. Ricketts.

2. *Proceedings of Scientific Societies,*

Proceedings of the Colorado Scientific Society, vol. iii, part ii, 1889, contains: Remarks on the plication of the coal measures in southeastern Colorado and northeastern New Mexico, P. H. Van Diest; Etched beryls from Mt. Antero, Colorado, R. C. Hills; Analyses of three descloizites from new localities, W. F. Hillebrand; Notes on the aboriginal remains near Denver, Colorado, Geo. L. Cannon, Jr.: The plasticity of glacier ice, John F. Main; Stereo-chemistry, Chas. S. Palmer; Additional notes on the Huerfano beds, R. C. Hills; Additional notes on the eruptions of the Spanish Peaks region, R. C. Hills; Notes on the occurrence of sesqui-sulphate of iron in New Mexico, Richard Pearce; Sublimated tellurium, Richard Pearce; Preliminary paper on the eruptive rocks of Boulder county, and adjoining counties, Colorado, Chas. S. Palmer; and the address of the retiring president (Richard Pearce) on the Paragenesis of the gold-bearing ores.

Contributions to the Tertiary fauna of Florida, with special reference to the Miocene silex-beds of Tampa, and the Pliocene beds of the Caloosahatchie river. W. H. Dall, (vol. iii, of the Trans. of the Wagner Free Institute, Philadelphia).

3. *Papers in Scientific Journals.*

The Ottawa Naturalist, *Sept.*, 1890. Serpentines of Canada, N. Jiroux; *Oct.*; Ideas on the beginning of life, J. Ballantyne.

Bulletin of the American Geographical Society, vol. xxii, No. 3, *Sept.*, 1890, contains: Canada, the land of waterways, Watson Griffin; Modern

Iceland, C. S. Smith ; Some notes on the upper Amazon, Courtenay De Kalb.

The American Antiquarian, *Sept.* contains: The difference between Indian and Mound-builders' relics, Stephen D. Peet ; Symbolism among the dolmens and standing stones of France, A. S. Packard.

American Naturalist, *Sept.* No., Newly discovered glacial phenomena in the Beaver valley, P. Max Foshay and R. R. Rice.

Proceedings of the Can. Institute, Toronto, *April*, 1890. Geology of the northwest of Lake Superior, Arthur Harvey ; Kamanistiquia silver-bearing belt, Herbert R. Wood.

Am. Jour. Sci., *Aug.* No. : Curious occurrence of vivianite, W. L. Dudley ; Classification of the glacial sediments of Maine, Geo. H. Stone: Some Lower Silurian graptolites from northern Maine, W. W. Dodge ; Siderite basins of the Hudson River epoch, James P. Kimball ; Two new meteorite irons, F. P. Venable ; Notice of some extinct testudinata, O. C. Marsh. *Sept.* : Rocky Mountain protaxis, and the Post-Cretaceous mountain-making along its course, J. D. Dana ; Chalcopyrite crystals from the French Creek iron mines, Chester Co., Pa., L. S. Penfield ; Koninckina and related genera, C. E. Beecher ; Notice of two new iron meteorites from Hamilton county, Texas, E. E. Howell ; The Cretaceous of Manitoba, J. B. Tyrrell ; On mordenite, L. V. Pirsson ; Geology of Mon Louis island, Mobile bay, D. W. Langdo ; On Leptænisca, a new genus of brachiopod from the Lower Helderberg group, Chas. E. Beecher ; North American species of Strophalosia, Chas. E. Beecher ; Notes on the Microscopic structure of oölite, with analyses, E. H. Barbour and Joseph Torrey, Jr.

4. *Excerpts and individual publications.*

The crystalline structure of the Coahuila irons, Oliver W. Huntington, Proc. Am. Acad. Arts and Sciences (N. S.), vol. xvi, p. 30.

Eruptive rocks from Montana, Waldemar Lindgren, Proc. Cal. Acad. Sci. series 2, vol. iii.

Notes on the geology and petrography of Baja, California, Mexico. Waldemar Lindgren. Proc. Cal. Acad. Sci. series 2, vol. iii.

Bibliography of North American Paleontology for 1886. John Belknap Marcou. From the Smithsonian report for 1886–87.

Artesian wells, Atlantic City, N. J., Lewis Woolman. From the annual report of the state geologist, 1889.

Geology of artesian wells at Atlantic City, N. J., Lewis Woolman, Proc. Acad. Nat. Sci. Phil. Mar. 25, 1890.

The Calcіocrinidæ, a revision of the family, with descriptions of some new species. Eugene N. S. Ringueberg, M. D., Annals N. Y. Acad. Sci., vol. iv, 1889.

The Crinoidea of the Lower Niagara limestone at Lockport, N. Y., with new species. Eugene N. S. Ringueberg. Annals N. Y. Acad. Sci. July, 1890.

A brief description of the Cretaceous rocks of Texas and their economic value. Robert T. Hill. From the First annual report of the Texas Geological survey.

Electro-chemical Analysis, Edgar F. Smith, 16 mo., pp. 116, P. Blakiston, Son and Co., Philadelphia.

The persistence of plant and animal life under changing conditions of environment. Persifor Frazer, The American Naturalist, June, 1880.

On variation, with special reference to certain paleozoic genera, Jos. F. James, The American Naturalist, December, 1889.

On the geology and physiograghy of a portion of northwestern Colorado and adjacent parts of Utah and Wyoming, C. A. White. Ninth annual report of the director, U. S. Geol. Sur.

Some metamorphosed eruptives in the crystalline rocks of Maryland, Wm. H. Hobbs, (Trans. Wis. Acad. Sci., Arts and Letters, vol. viii, pp. 155–159).

Some Ontario magnetites, T. D. Ledyard. (Trans. Am. Inst. Min. Eng.).

A summary of progress in mineralogy and petrography in 1889, W. S. Bailey (From monthly notes in the American Naturalist).

The first oil well, the birth of a great industry, J. S. Newberry. (Harper's Magazine, Oct., 1890).

Discovery of fossils in the limestones of Frederick county, Md., Charles R. Keyes (Johns Hopkins University circulars, No. 83).

Description of new meteorites, by E. E. Howell, (Proc. Rochester Acad. Science, vol. i). The meteorites described are Welland, Hamilton, Puquois, De Cewsville, Dona Inez and Llano del Inca, El Chanaralino, La Primitiva and Calderilla.

Barometric observations among the high volcanoes of Mexico, with a consideration of the culminating point of the North American continent, A. Heilprin, (Proc. Acad. Nat. Sci. Phil., Oct., 1890).

On Syringotheris, Winchell, and its American species, Charles Schuchert, (Ninth annual Report N. Y. state geologist, 1890).

List of species of the American paleozoic Orthis, Spirifera, Spiriferina and Syringotheris, Chas. Schuchert, (Ninth annual Rep. N. Y. state geologist).

Notes on the serpentinous rocks of Essex county, N. Y., from aqueduct shaft 26, New York City, and from near Easton, Penn., Geo. P. Merrill (Proc. U. S. Nat. Museum, vol. xii, pp. 595–600).

On certain Mesozoic fossils from the islands of St. Paul's and St. Peter's in the straits of Magellan, C. A. White, (Proc. U. S. Nat. Mus. vol. xiii, pp. 13–14).

Description of new forms of Upper Cambrian fossils, C. D. Walcott, (Proc. U. S. Nat. Mus. vol. xiii, pp. 266–279).

5. *Foreign publications.*

Faune du calcaire D'Erbray (Loire inférieure). Par CHARLES BARROIS. Contribution à l'étude du terrain Devonien de l'ouest de la France. Mem. Soc. géol. du Nord. Tome troisième, 1889.

Geologische Untersuchungen am Westabhange des Urals. Von A. KARSNOPOLSKY (mit 2 Tafl. u. 15 Holzsch. im Texte). Mem. du Comité géologique, St. Petersburg, 4to., 522 pp.

Die geol. Erforsch. des auf d. 48-sten Blatt der allgemeinen geologischen Karte Russland's dargestellten Gebietes. Krystallinische Gesteine. Das Kreidesystem. Das tertiäresystem. Pliocän. Das posttertiäresystem. Mem. d. Comité Geol. Russlands, 4 to. 262 pp.

The twenty-seventh volume of the Oberhess. Gesell. f. Natur und Heilkunde contains the following geological papers: Neue Funde von Mineralien, Gesteinen und Versteinerungen aus der Umgegend von Giessen, A. STRENG; Ueber den Melanophlogit, A. STRENG; Eine neue Limatula aus dem Oligocän des Mainzer Beckens, G. GREIM; Ueber eine eigenthümliche Säulenbildung im Tagebau des Braunsteinbergwerks in der Lindener Mark, J. UHL; Ueber Regentropfenspuren ebendaselbst, J. UHL.

Annales de la société géologique du Nord, tome xvi, 188-89, contains: Observations sur la constitution géologique de l'ouest de la Bretagne (III). Chas. Barrois; Les dépots phosphatés de Montay et de Forest, J. Ladrière; Grès dit Porphyre de Gognies-chaussée, L. Cayeux; Leçons sur les gites de Phosphate de chaux du Nord de la France, M. Gosselet; Le bassin houiller de Valenciennes d'apres les travaux de MM. A. Obry et R. Zeiller, Ch. Barrois; L'Age des Sables de Cerfontaines et de Rousies, L. Cayeux; Sur la présence de Trilobites dans les schistes rouges-lie-de-vin des environs de Rennes, Bézier; L' Ardenne, J. Gosselet; Les crustacés dévoniens de l'état de New York, d'apres M. James Hall, Ch. Barrois; Sur le Panisélien du Mont-des-chats, A. Boussamaer; Le Faune du Tun, extension en épaisseur de la zone à Micraster breviporus, L. Cayeux; Note sur l'existence du terrain dévonien supérieur à Rostellec, Ch. Barrois; Crétacé de Chercq près Tournay, L. Cayeux: Nature et origine des phosphates de chaux par R. A. R. Penrose, L. Cayeux. Coupe prise à Arques, Achille Six; Leçons élémentaires sur la géologie du Department du Nord, J. Gosselet; Sur la Ciplyte, J. Ortlieb; Déscription géologique du canton d' Avesnes-Nord, L. Cayeux; Un cas de stratification entrecroissée des limons à Cysoing, L. Cayeux; Structure de la bande de Calcaire carbonifère de Taisnières-sur-Helpe, L. Cayeux.

Contribution à l'étude des roches metamorphiques et éruptives de l'Ariège, A. Lacroix; Sur les enclaves acides des roches volcaniques de l' Auvergne, A. Lacroix, (Bul. d. services. Carte Géol. de France, No. 11, tome II, Avril, 1890).

Annales géologiques de la péninsule Balkanique (dirigées par J. M. Zujovic), tome II, contains the following in French and German: Note sur la meteorite de Jelica, tombée 19 Novembre (1 Decembre) 1889, J. M. Zujovic; Die Mediterranstufe von Rakovica, P. S. Pavolic; Les lampophyres de Serbie, J. M. Zujovic: Les roches éruptives aux environs de Sophia, Milos St. Dinic; Analyses des eaux (par Sima Lozianic) et de quelques minéraux de Serbie (par M. Biargojevic).

Eclogæ geologicæ Helvetiæ, vol II, No. 1, contains: Geologischen Mittheilungen aus der Umbebung von Lugano. C. Schmidt u. G. Steinmann; Ueber ein zweites Vorkomenen von dichtem Vesuvian in dem Schweitzeralpen, C. Schmidt.

Földtani Közlöny, der ungarischen geologischen Gesellschaft, Bd. xx, 5–7 heft, contains, in the supplement: Spuren des Höhlenbären (Ursus spelæus Blum.) in Ungarn, G. Primics: Dicksonia punctata Stbg. sp. in der fossilen Flora Ungarns, M. Staub:

Mittheilungen des Vereins für Erdkunde zu Leipzic, 1889, contains: Physikalische und geologische Verhältnisse des Chiemsees, E. Bayberger; Stabsarzt Dr. Ludwig Wolf, Friedrich Ratzel, with a portrait;

Bulletins du comité géologique, St. Petersbourg, vol. viii, Nos. 9–10, contains: Récherches microscopiques sur les roches et minerais du gisement Sawodinskoïe (Altai), Mikloucho–Maclay. Vol. ix, Nos. 2–3, contains: Note sur le calcaire Carbonifère du bassin de Moscou, S. Nikitin. Vol. ix. No. 5, contains: Note sur les gisements des minerais de fer dans le district de Berdimsk du government de Tauride, N. Sokolov. Bibliothèque géologique de la Russie, 1889, Supplement to vol. ix.

Neuere Breiträge zur Epigraphie des dacischen Erzgebirges und Bergbaues, G. Teglas.

Mittheilungen der naturforschenden Gesellschaft in Bern, aus dem Jahre 1889, contains: Löss und lössähnliche Bildungen in der Schweiz, Fr. Jenny: Ueber den Hautschild eines Rochen aus der marinen Molasse, A. Baltzer:

Transactions of the Edinburgh Geological Society, vol. vi. Part i, contains: Darwin's geological work, Ralph Richardson; The classification, distribution, origin and evolution of the normal micas, Alexander Johnstone; Note on the supposed high-level shell beds in Easter Ross, Hugh Miller; On the succession of the Lower Carboniferous series to the West of Edinburgh, with special reference to the district around Cramond, John Henderson; An old man and woman, or Human bones in a Scrobicularia bed at Newton Abbot, Devonshire, William Pengelly: Improvements in the methods of determining the composition of Minerals by blowpipe analysis, Alexander Johnstone; Recent progress in paleontology as regards invertebrate animals, H. A. Nicholson.

On composite spherulites in obsidian, from Hot Springs near Little lake, California, Frank Rutley (Quart. Jour. Geol. Soc. vol. xlvi. Aug., 1890).

Class-book of Geology, Arch. Geikie, 2nd edition, 12mo, 404 pp. Memillan & Co., London and New York.

Reports of geological explorations during the years 1888–9 (New Zealand), Wellington, 1890. James Hector, director. Besides the report of progress by the director, there are lengthy reports by A. McKay and J. Park. Large octavo, numerous illustrations and maps.

6. Scientific Laboratories and Museums.

Bulletin of the scientific laboratories of Denison University, vol. v, contains: The Waverly group, W. F. Cooper: Tabulated list of fossils known to occur in the Waverly group of Ohio, W. F. Cooper.

Bulletin of the American Museum of Natural History, vol. iii., No. 1, contains: The Calciferous formation in the Champlain valley, Brainerd and Seely: Observations on the fauna of the rocks at Fort Cassin, Vermont, with descriptions of a few new species: Observations on a

fossil fish from the Eocene beds of Wyoming, R. P. Whitfield; Description of a new genus of inarticulate brachiopodous shell, R. P. Whitfield.

Bulletin from the laboratories of natural history of the state university of Iowa, contains the conclusion of the paper by B. Shimek on the Loess and its fossils.

Bulletin of the Mus. Comp. Zool., Cambridge, vol. xvi., No. 9, On keratophyre from Marblehead neck, Mass., John H. Sears.

CORRESPONDENCE.

PLEISTOCENE SUBMERGENCE OF THE ISTHMUS OF PANAMA. Since the printing of my article in this number, I have found the original report of Dr. G. A. Maack, which forms pages 155–175 of Reports of Explorations for a Ship Canal, Isthmus of Darien, Navy Department, Washington, 1874. This strongly confirms my suggestion that at least the lower parts of the isthmus were probably submerged during the Glacial period; for the fossils collected by Dr. Maack are described by him as "still living in the sea," and "all living up to the present time," showing the formation to be of Pleistocene age. He does not, however, use this designation, nor yet the term Pliocene, which is applied to these fossils by another writer in Harper's Magazine; instead of which. Dr. Maack refers them to "the later Tertiary formation," and "the latest Tertiary deposit," remarking that it "was covered by the sea comparatively a short time ago." "This Tertiary formation seems to have a vast extent and to spread over the dividing ridge" [between the Tuyra and Atrato rivers, tributary respectively to the Pacific and the Atlantic], "the lowest elevation of which was found to be 763 feet." It appears therefore almost certain that much of this isthmus was submerged in the Pleistocene period, which included the Ice Age of glaciated countries. The part of the warm equatorial current which now passes northward from the Caribbean sea and Gulf of Mexico was then permitted to continue westward into the Pacific; and this change in the oceanic circulation may have been largely efficient, in conjunction with high continental elevation, to bring about the climatic conditions of the Ice Age.

Somerville, Nov. 12, 1890. WARREN UPHAM.

STUDIES ON MONTICULIPORA. In the August number of the GEOLOGIST there appeared an article under the above title by Dr. C. Rominger. The writer reviews the labors of Dr. H. A. Nicholson and Mr. E. O. Ulrich upon the Monticuliporidæ and gives observations and conclusions of his own corroborating or contradicting those of these authors. On the whole the doctor seems well satisfied with the work of Nicholson, while that of Mr Ulrich gave him a "prostrating giddiness," to use his own expression, from which he does not seem to have entirely recovered when he wrote the article in question. Mr. Ulrich has but carried out

to a legitimate conclusion the method of Dr. Nicholson and why cannot Rominger follow unless it is that he is timid about venturing away from his ancient land marks. On a previous occasion Mr. Joseph James (*vide* Journal of the Cincinnati Society of Natural History, vol. x. p. 118 et seq.) found fault with Mr. Ulrich's subdividing so extensively the genus Monticulipora and giving each division a generic rank, deeming it a useless cumbering of nomenclature, and productive of endless confusion in the study of a confessedly difficult group of fossils.

These attacks on the new method of dealing with the monticuliporoids and other paleozoic Bryozoa, could be suffered to pass unnoticed, were it not that the host of onlookers might think Mr. Ulrich stood alone in the conflict. It is not so, Mr. Aug. F. Foerste and Mr. A. H. Foord have used this method of work in their labors on the Bryozoa. The new method will prevail. It is but the outcome of a more correct understanding of nature and her ways of working. And the periodical objections of those used to the old ways and unable to catch the spirit of the new, are to be expected and are as harmless to real progress as youth's first love to his eventual well being.

That the external characters of the monticuliporoids are insufficient for classification and produce artificial assemblages no longer needs proof. Those who base their classification upon internal characters and structure do not neglect the external features nor hesitate to make use of them whenever possible. Often external characters are correlated with internal but not always. That Dr. Rominger has failed to grasp Mr. Ulrich's genera should not induce him to hastily charge the failure to the genera. It may be due to his own lack of perceptive powers. And that the effort should have produced in him a "dreadful agony near to fainting" arouses one's pity.

We may notice more in detail some of Dr. Rominger's statements. He speaks of "trifling modifications." This seems a clear case of trying to belittle points of difference. What is it that makes a modification "trifling?" Who shall say that the presence or absence of acanthopores (spiniform corallites of Rominger) does not betoken some difference and perhaps a great one, in the anatomical structure. The view advanced by Dr. Rominger to explain the origin of the spiniform corallites, for which Nicholson and Foord have proposed the term acanthopores, seems to me entirely unsupported by the evidence he offers. The majority of observers have considered these to be tubules, which in some cases the doctor admits; but he says the center is not well defined and so thinks they were not regular tubules tenanted by peculiarly modified zooids, as Dr. Nicholson conjectures, or vibracula as Mr. Ulrich supposes, but were formed by a superabundance of schlerenchyma in certain parts of the wall tissue; basing this view upon the manner in which the walls are formed of layers projecting obliquely upward and outward. He argues that if they were tubules in structure, they should have been constructed in the same manner as the others. But why? It would seem a reasonable supposition that the tubule, if the home of an appendage of the nature of a vibraculum, as is probable,

would as the zoarium grew need to keep near the surface and the tubule would be gradually abandoned behind it and filled up; and thus the originally hollow part not be sharply defined. If "the spinules are an integrant part of the ordinary tube-walls, whose margins by exuberance in secretion of shell matter, form nodular prominences in certain spots of their circumferences, which, amalgamating with similar prominences of adjoining tube-walls, constitute the spinules," why does it happen that such apparently purposeless exuberant secretion of adjoining walls always happens at the same place so as to form a tubule. I cannot see either how these tubules would always be so regular in form and constant in position and numbers as observation proves them to be.

Sections show, so far as the nature of preservation will permit, that acanthopores are built up in the same manner as the zooecia, *i. e.*, of laminar inverted cone-shaped layers. Furthermore Nicholson has shown diaphragms in the acanthopores of Batostomella gracilis James (Genus Monticulipora, p. 126, fig 20E.), and Mr. Ulrich has observed them in other forms. Waagen and Wentzel consider the acanthopores as merely young tubules.

The doctor states that "in parts of one and the same specimen spinules are often abundantly developed, while in other parts of the surface they are entirely missing or only thinly scattered," and regards this as a satisfactory indication that their functional importance cannot be very great. His observation is correct. Some specimens show them over part of the surface and missing on other parts. But this is due to a peculiar state of preservation or fossilization. Tangential sections invariably prove that originally the specimen had the spines equally developed on all parts of the surface. The acanthopores are there though the surface projections are gone; hundred of sections of spinulose forms demonstrate their constancy and stability; hence the presence or absence of acanthopores is a character of good classificatory value.

In the main Dr. Rominger approves of Prof. Nicholson's making subdivisions of the genus but considers the lines very artificially drawn. Apparently he objects to raising the divisions to the rank of genera. But what difference does it make whether we call a division a subgenus or genus. Each is but an assemblage of species having certain points in common. And certainly a binomial nomenclature is preferable to a trinomial one. A genus is not an entity nor is there such a thing in nature. It is but a convention adopted for the easier understanding and discussion of nature. When Mr. Ulrich, recognizing the incongruity of Prof. Nicholson's assemblages, forms genera based upon the aggregate of characters and attempts with success to bring together species whose features indicate a natural relationship, the doctor suddenly loses faith in the method.

In speaking of Dekayia the doctor holds that "a distinction of forms with large and more distant spinules from those with smaller ones is as vague as the difference between large and small, without a defined standard of magnitude for comparison." This is disingenuous. There

is no difficulty whatever in distinguishing the large acanthopores of Dekayia from the smaller ones of other monticuliporoids and that too "without a defined standard of magnitude." But were this so, the genus Dekayia is not based on this feature alone but upon others also.

Diplotrypa and Prasopora our author would throw together because by making incomplete vesicular diaphragms (cystiphragms) occur in Diplotrypa and complete diaphragms in some of the tubes of Prasopora, he can find no essential point of difference. But his observation, if ever he has made any on these genera, is wrong. Every specimen of Prasopora always has cystiphragms and no specimen of Diplotrypa ever has them. If his sections of Prasopora sometimes show straight diaphragms in the zoœcia, this is due to the manner in which the section is made. The cystiphragms form a continuous row lining one side of the zoœcial cavity. A longitudinal section through the zoœcial chamber in one direction cuts all the cystiphragms; made at right angles it cuts none of them but does cut the diaphragms which are also found in the zoœcial chamber. Hence the doctor has hastily concluded that such tubes contain no cystiphragms. Other differences between the genera might be pointed out, but I have no desire to write a treatise on the subject here. By a similar process of minimizing and overlooking differences, the doctor would discard Peronopora.

When Mr. Ulrich in defining the genus Atactoporella sums up the characters distinguishing it from Atactopora, and uses the phrase "these are all good generic characters," he is not seeking consolation for establishing a new genus, but is showing how per force a new genus must be established. The summary which Dr. Rominger gives of Mr. Ulrich's genera is garbled and hypercritical and to the highest degree unjust. If Lioclema does not belong to the monticuliporoids, where will the doctor put it? There is no questioning its relation to Batostomella.

If the doctor were seriously called upon to deal with the 250 described species, besides an additional host of forms known but as yet undescribed, all of which from his standpoint would have to be placed under Monticulipora, would he not be very apt to split up the genus? And if so, would he call the groups genera or subgenera? It is strange that in every instance where it is likely that he has had an opportunity to fully study certain types, his conclusions approximate those of Mr. Ulrich: for instance, Callopora, Fistulipora, Lioclema, Stenopora, all of which he accepts and seems inclined to magnify their distinctness. If he had sufficiently ample material and the wish and energy to subject it to full investigation, would he not out-Ulrich Ulrich himself.

And finally this ought to be said that Dr. Rominger ought to have been fair enough to have waited before passing sentence of condemnation until the result of Mr. Ulrich's mature studies should appear in volume viii. of the Geological Survey of Illinois, a perusal of which may have the effect of considerably modifying his views.

Sparta, Ill., Sept. 25, 1890. J. M. NICKLES.

DATA FOR THE DETERMINATION OF EARTH MOVEMENTS. As I was at one time connected with the Pensylvannia railroad, I am well acquainted with the accurate methods of their engineering corps, and the statement in one of our papers, during the last year, that some of the corps were verifying the accuracy of certain bench marks, that were supposed to be inaccurate, made me think that it would not be a bad idea for our United States Geological Survey to obtain copies of the bench marks of the dozen, or more, trunk lines that cross the mountains of the Atlantic and Pacific borders, with the dates of survey by which they were established. If we study earth movements near the sea, we have a datum line for ready reference. A persistence in a variation in the bench marks of a definite region, that are connected with tide, will indicate an earth movement with great accuracy, and a careful collation of the records of the various level surveys of the railroads noted will, in time, furnish data for a complete discussion of the question.

Yours truly,

EDWARD H. WILLIAMS, Jr.

Lehigh University, Bethlehem, Pa., Nov. 13, 1890.

THE IROQUOIS BEACH. In reading Prof. Spencer's essay on the Iroquois Beach, referred to in your November number, I notice his comparison of the ancient lake Iroquois with the present gulf of Obi, his idea being that these sheets of water are alike in having open connection with the sea. But is it not true that rivers run only *into* the gulf of Obi, while a large river ran *out of* lake Iroquois, its course having been southwestward across the state of Ohio? If this ancient outlet of lake Iroquois to the southwest is proved, must we not suppose that the northeastern end of the lake was some how cut off from the Atlantic? The case is the same with the expanded lake Ontario, which appears to have overflowed to the southeastward into the Mohawk.

Cambridge, Nov. 5, 1890. W. M. DAVIS.

CARCINOSOMA NEWLINI. Finding that the name Eurysoma, proposed in the October number of the GEOLOGIST, was preoccupied in Europe in 1886, I desire to substitute for it the name *Carcinosoma*. The new species described from Kokomo, Indiana, will, therefore, now bear the name *Carcinosoma newlini.* E. W. CLAYPOLE.

PERSONAL AND SCIENTIFIC NEWS.

THE ORGANIZING COMMITTEE OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS met at the Institute of Technology in Boston, November 13th, 1890.

Messrs. Chamberlin, Davis, Gilbert, Hall, Hazen, Hitchcock, Powell, Newberry, Shaler, Stevenson, Winchell and Williams were present.

The secretary reported the vote of the London Bureau regarding the change of place from Philadelphia to Washington. Thirty-

six ballots were received; of these thirty-three were in favor of Washington.

These represent the members from Great Britain, France, Germany, Australia, Austria, Belgium, Hungary, India, Italy, Portugal, Roumania, Russia, and the United States. No negative votes were received from countries outside America.

The majority of the Bureau, as well as a majority of the American Committee, thus expressing their preference for Washington, it was voted to hold the next session of the International Congress of Geologists in Washington, during the week beginning with the last Wednesday (26th) of August next.

The vacancy in the committee caused by the death of Mr. C. A. Ashburner, was filled by the election of Mr. S. F. Emmons, Washington, D. C.

The committee now consists of the following members: Messrs. Branner, Chamberlin, Dana, Dutton, Davis, Emmons, Gilbert, Hall, Hague, Heilprin, Hitchcock, Leidy, Lesley, Le Conte, Marsh, Newberry, Powell, Proctor, Shaler, Stevenson, A. Winchell, Walcott, Whitfield and H. S. Williams.

During this meeting vacancies were filled and the organization of the Committee perfected, so that the present officers and sub-committees are as follows:

Chairman,	J. S. Newberry,	New York City.
Vice-Chairman.	G. K. Gilbert.	Washington, D. C.
Secretaries,	H. S. Williams,	Ithaca, N. Y.
	S. F. Emmons,	Washington, D. C.
Acting Treasurer.	S. F. Emmons,	Washington, D. C.

(1) A sub-committee on the *Scientific Programme:*

J. W. Powell, Chairman,	Washington, D. C.
J. D. Dana,	New Haven, Conn.
T. C. Chamberlin,	Madison, Wis.

(2) A sub-committee on *Longer Excursions:*

Clarence Dutton, Chairman,	Washington, D. C.
N. S. Shaler,	Cambridge, Mass.
J. J. Stevenson,	New York City.

(3) A local sub-committee to make preparations for holding the meeting in Washington, with power to organize and add to their number:

Messrs. Dutton, Gilbert, Hague, Emmons, Powell, and Walcott, all of Washington, D. C.

(4) A nominating sub-committee to nominate officers for the Congress:

J. J. Stevenson, Chairman,	New York City.
T. C. Chamberlin,	Madison, Wis.
Alex. Winchell,	Ann Arbor, Mich.

The following resolutions were adopted:

That the secretaries be authorized to prepare a circular of information, stating the organization, the time of meeting, and such

other information regarding the Congress as may be thought necessary, in English and in French, to be signed by the chairman and the secretaries, and distributed among those likely to be interested in this country and in foreign countries.

It was further resolved, that the secretary be authorized to communicate to the editors of the AMERICAN GEOLOGIST and the *American Journal of Science* the results accomplished by the committee at the present meeting.

And it was resolved, that the committee assess its members five dollars each for expenses.

AT THE MEETING OF THE BOSTON SOCIETY OF NATURAL HISTORY, Nov. 5, 1890, Mr. George H. Barton spoke of his work the past summer in mapping the drumlins of Massachusetts, under the direction of Prof. N. S. Shaler, for the U. S. Geological Survey. The area traversed, which includes several hundred drumlins, is a belt fifteen to thirty miles wide, extending from Lowell west to the Connecticut river.

DAKOTA'S RICH TIN MINES. The Harney Peak Consolidated Tin Company lately sent to England 17¾ tons of tin ore to be smelted. A report from the smelters states that they obtained from this ore, 12 cwts., 1 qr., 14 lbs. of refined tin, which is 3.48 per cent. As the Cornish mines only yield about 2 per cent., it would appear that we have superior advantages in this country for the production of tin, which, since we are about to enter upon making our own tin plate, is to our advantage.

VALUABLE PEARLS have been taken from the Manitowoc river in large quantities recently, at Chilton, Wis. They are said to be of all colors, and some of the choicest have had a high value placed on them.

PROF. JOHN C. SMOCK HAS RESIGNED in the New York State Museum and has accepted the appointment of state geologist of New Jersey.

MR. F. J. H. MERRILL, OF NEW YORK CITY, has been appointed assistant state geologist of New York, and will continue work on the economic resources of the state, and upon the geological map.

GATHERING OF SCIENTISTS. The American Association for the Advancement of Science adjourned at Indianapolis to meet next year in Washington, probably about September 1. The next session of the International Congress of Geologists will also be held at the same place about the same time. The semi-annual meeting of the Geological Society of America will, by its own constitution, hold its summer meeting at the same time and place. Prominent scientific men of Canada and the Latin countries to the south have been invited by the officers of the Association with a view of making this scientific gathering a great pan-American event. It will in all probability be one of the most important meetings of scientific men ever held on this continent.

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